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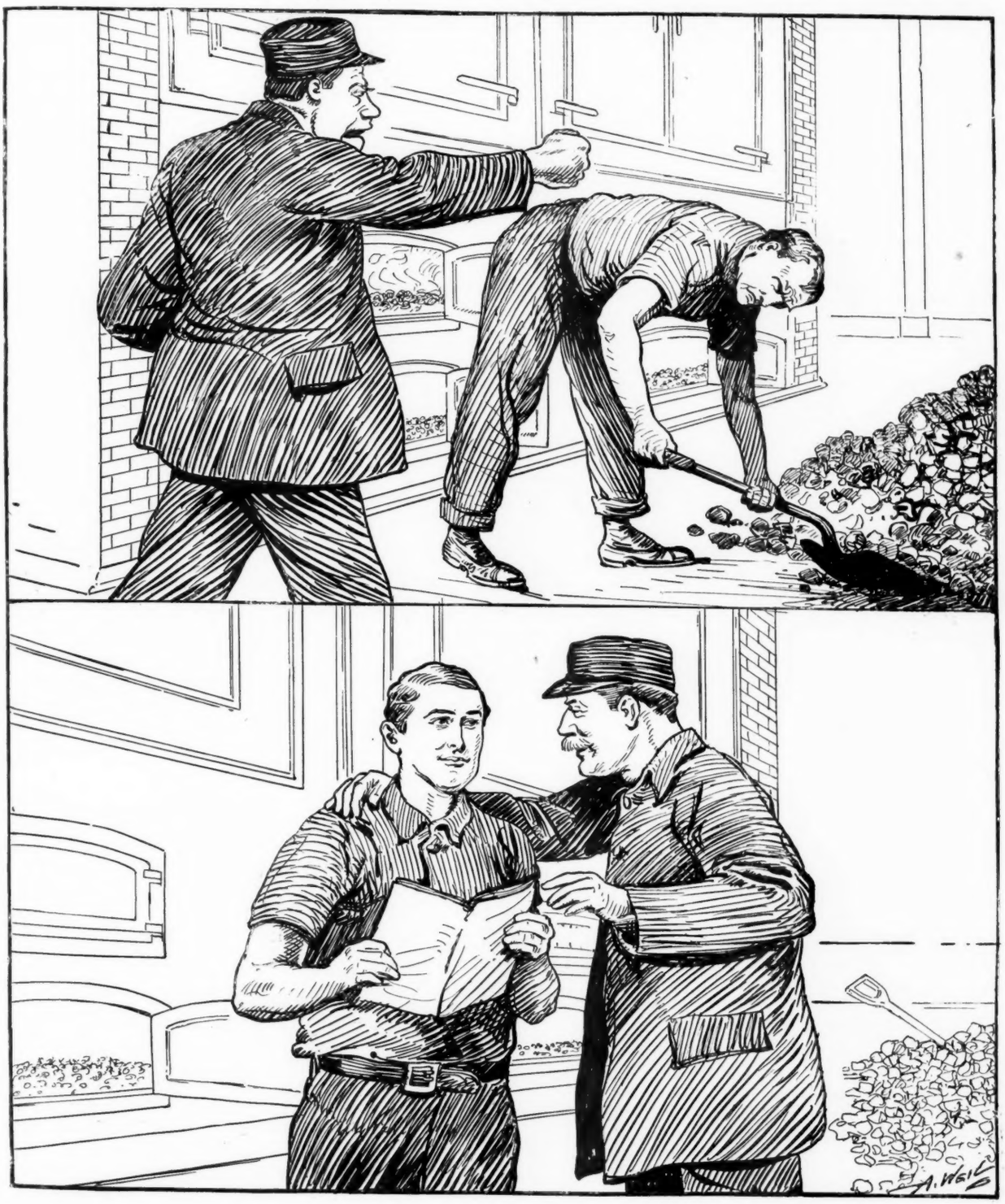

Two Methods of Persuasion

The Operation of a Gearless Traction Elevator

The Parts of a Direct-Traction Elevator Machine and their Functions

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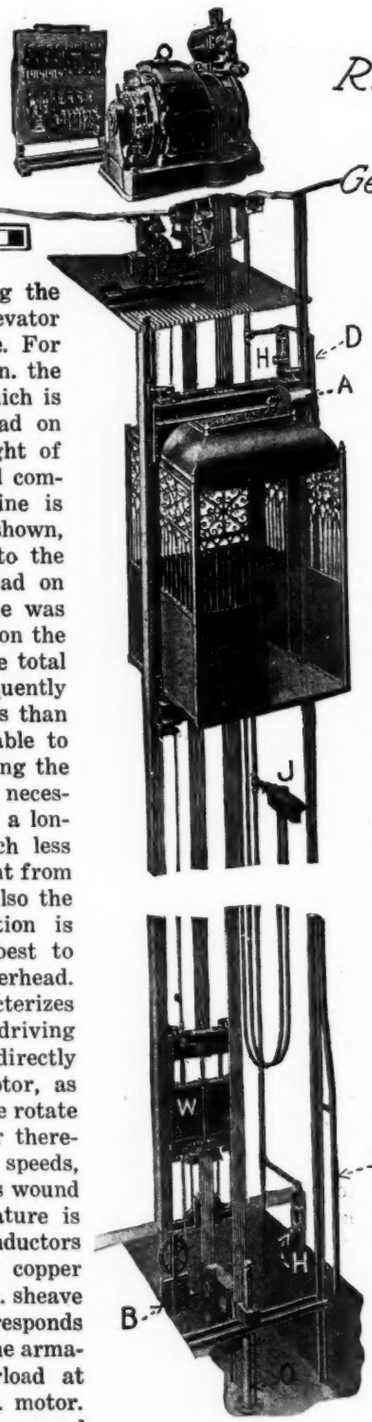


A COMPLETE installation using the 1:1 gearless-traction type elevator machine is shown on this page. For a duty of 2500 lb. at 700 ft. per min. the machine weighs about 16,000 lb., which is considerably less than the total load on the hoisting ropes, due to the weight of the counterweight, car, hoisting and compensating ropes. When the machine is placed on the overhead beams, as shown, the load on the building is equal to the weight of the machine plus the load on the hoisting ropes. If the machine was placed below, as in Fig. 3, the load on the overhead sheaves would be twice the total load on the hoisting ropes, consequently as the weight of the machine is less than the hoisting-rope loads it is desirable to place the machine overhead. Locating the machine overhead also obviates the necessity for extra sheaves, consequently a longer rope life is obtained and much less roping is required, as will be apparent from a comparison of Figs. 1 and 3. Also the over-all efficiency of the installation is higher. Therefore it is always best to locate gearless-traction machines overhead.

The particular feature that characterizes this type of installation is that the driving sheave and brake wheel are pressed directly on the armature shaft of the motor, as indicated in Figs. 1 and 5, and hence rotate at the motor's speeed. The motor therefore must be built for very slow speeds, and generally has six or eight poles wound with shunt field only. The armature is series wound with rectangular conductors to get the maximum amount of copper in the armature slots. With a 36-in. sheave a car speed of 600 ft. per min. corresponds to 63.6 revolutions per minute of the armature. To handle a 2500-lb. carload at this speed requires about a 38-hp. motor. The dimensions of the motor are several times larger than those of a machine of this horsepower built for 600 revolutions per minute. With the standard type of traction machine it is necessary to use a secondary or idler sheave *F*, Figs. 1, 2 and 5, so that the hoisting ropes can be given approximately two half-wraps around the driving sheave to obtain the necessary traction. In general six ⅝-in. extra-flexible steel ropes are used for hoisting. As shown in the illustration on this page and also in Fig. 1, these ropes are led from the car to the driving sheave, where they make one half-turn, then to the idler or secondary sheave and back to the driving sheave for another half-turn, and then to the counterweight. In cases where the driving sheave does not span the center-to-center distance between the car and counterweight, as shown in Fig. 1, the secondary sheave *F* must be offset, as shown in Fig. 2, and used also to lead the ropes from the driving sheave to the counterweight. Consequently, in practice both the driving and secondary sheaves have 12 grooves cut in them. With the two half-turns around the driving sheave, slippage will not occur between the ropes and the sheave until the load on the car side is about twice that of the counterweight size, or vice versa.

The counterweight, which includes the counterweight buffer, is adjusted so that it equals the total weight of the car and sling, plus 40 per cent. of the car load. Thus, for a duty of 2500 lb. the counterweight would weigh 1000 lb. more than the car and sling. With compensation as obtained by compensating ropes, shown in the complete installation and Figs. 1 and 2, the maximum difference between the tension on the counterweight and the car side of the hoisting ropes is 1500 lb. As the total load on both sides exceeds 16,000 lb., as mentioned previously, and as slippage will not occur until the load on one side is twice that of the other, it can be readily seen that the traction is positive and that there is no danger of slippage. In fact, the trac-

tion is as positive as if the ropes were wound on a spirally grooved drum, which would be impossible on account of the large amount of rope required, due to the high rise.

The adjustment of the hoisting ropes must always be maintained so that, if the car should overrun the bottom landing, the counterweights will not run into the overhead work, even after the combination oil and spring bumper, Figs. 1 and 2, in the pit is fully compressed, or if the car should overrun the top terminal landing, the counterweight bumper will strike its bumper blocks in the pit. If either the car or counterweight bottoms in the pit, the traction between the driving sheaves and ropes is lost. This makes the traction type of machine the safest of all modern elevators, as there is no danger of the car or the counterweights being drawn into the overhead work, even if the machine continues to run. An exception, however, occurs in very high rises when the great weight of the hoisting rope will cause considerable traction, even after the car or counterweight has landed on its bumper. This traction, together with the momentum of the car or counterweight, might cause either of them to run into the overhead work, especially where the overhead clearance is small. To prevent this, some of the high-rise installations are equipped with retarding devices, which come into action after a normal overrun is exceeded, and cause sufficient unequal loading on the hoisting cables at the driving sheave to create slippage and stop further motion.

In the complete installation and Figs. 1 and 2 compensating ropes are shown attached to the bottom of the counterweight and to the bottom of the car sling. It will be noticed that these ropes travel around a compensating sheave located in the pit at the bottom of the elevator shaft. This compensating sheave is free to move vertically, its housing being designed so that it can move up and down between guides in the pit. The compensating sheave and the housing are of heavy construction, so as to keep the compensating ropes under proper tension. This sheave also acts as a safety device, since, if either car or counterweight bottoms, further motion lifts the sheave and housing and thus tends to stop the car or counterweight from running into the overhead work. In addition, a switch is generally provided, which is opened when the sheave is lifted up a short distance. This switch in turn opens the main contactor *M* on the control board, Fig. 5, and stops the motor.

The hoisting and compensating ropes are each provided with self-adjusting swivel hitches of the ball-and-socket type, as indicated in Figs. 1 and 2. This permits

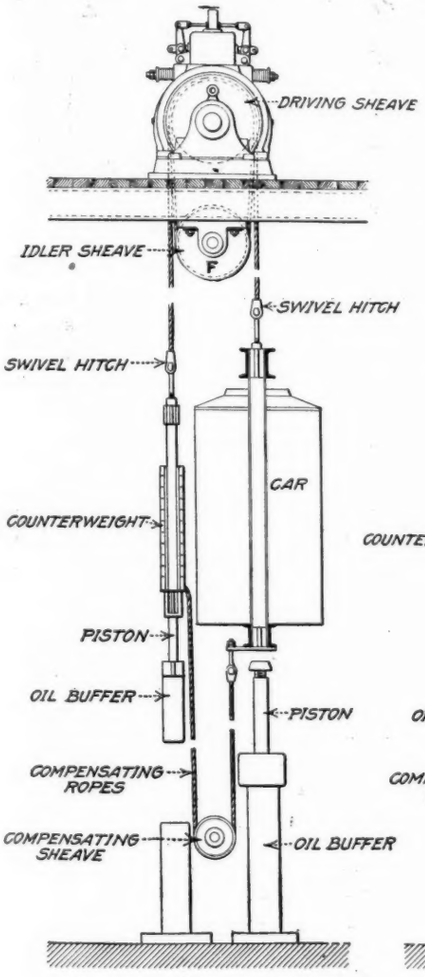


FIG. 1. INSTALLATION WHERE DRIVING SHEAVE SPANS HALF THE CAR WIDTH

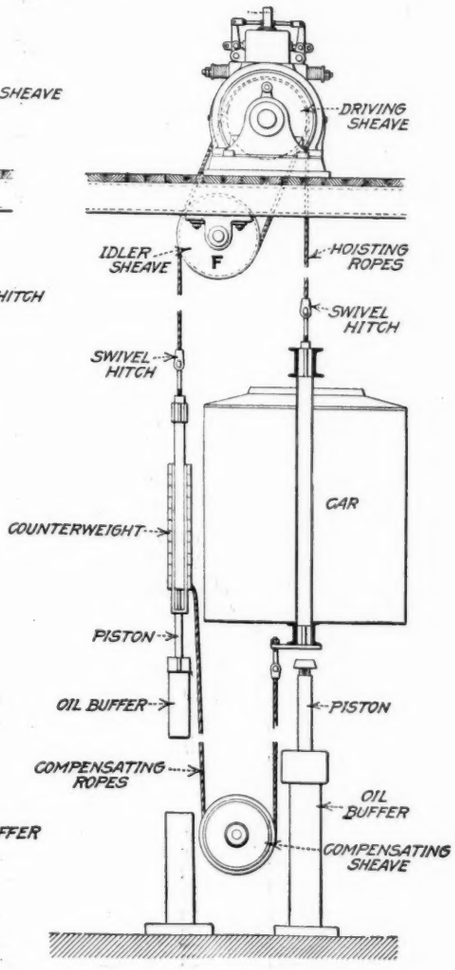


FIG. 2. INSTALLATION WHERE DRIVING SHEAVE DOES NOT SPAN HALF THE CAR WIDTH

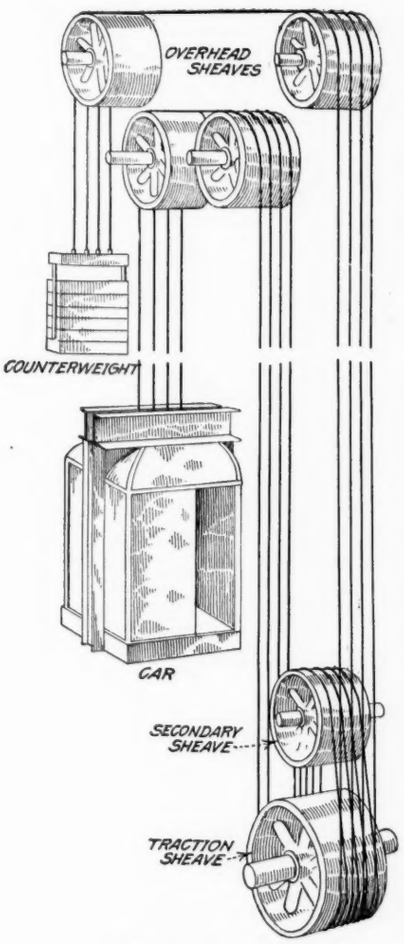


FIG. 3. INSTALLATION IN WHICH THE MACHINE IS LOCATED IN THE BASEMENT

of a gradual twisting or creeping of the ropes and prevents twisting strains at the hitches. In practice the ropes creep, owing to vibration and travel around the sheaves.

The compensating ropes compensate for the variation in the net load on the driving sheave, due to the shifting of the weight of the hoisting ropes from one side to the other that occurs during motion of the car up and down the hoistway. The weight of the compensating ropes must be such per foot that they will, with the electric cables leading to the car, compensate for the net shifting of load due to the weight of the hoisting ropes, regardless of the position of the car in the hoistway. Fig. 4 gives a sectional view of the oil-spring buffer used, as previously described, in the hoistway under the car and counterweight to assist in bringing them to rest in case the car overtravels the top or bottom landings. The retardation of the car or counterweight is brought about when either comes down on its buffer by the escape of oil from one chamber into the other of the buffer, through holes in the inner chamber indicated in the figure. When the buffer is unloaded, its piston is returned to its normal position by a spiral spring. The buffer is so constructed that it will bring the car to rest from full speed, when loaded, without discomfort.

FIG. 4. COMBINATION OIL-SPRING BUFFER

The brake wheel is generally of the same diameter as the driving sheave. The brake B is operated by a solenoid S, Fig. 5, so arranged that when the motor is energized the solenoid is also energized, and lifts the brake shoes off the brake wheel, against the tension of the brake springs T, by means of levers attached to the brake shoes and solenoid's cores. Inasmuch as, when the brake shoes are once lifted less current is required to hold them off the brake wheel, the solenoid's core levers operate a small switch W on top of the brake, which inserts a resistance in series with the solenoid to cut down the amount of current after the brake has been opened. The brake-shoe springs T are adjusted so that when the brake solenoid is not energized the pressure of the brake will hold full-load motor torque. With the slow-speed motor of 60 r.p.m. this torque is ten times as much as for a 600-r.p.m. motor of equal horsepower. Consequently, the brake must be of very heavy construction. Safe-lift machines for lifting heavy safes, etc., have two brakes, as shown in Fig. 6.

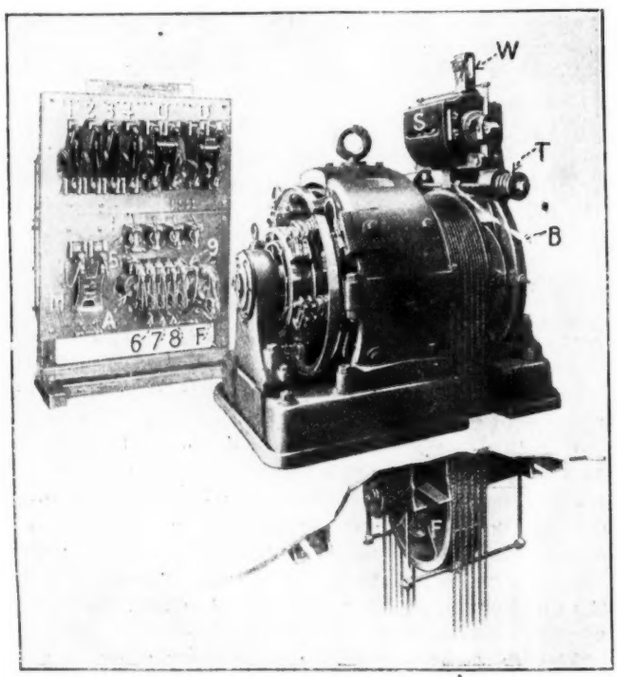


FIG. 5. GEARLESS-TRACTION ELEVATOR MACHINE

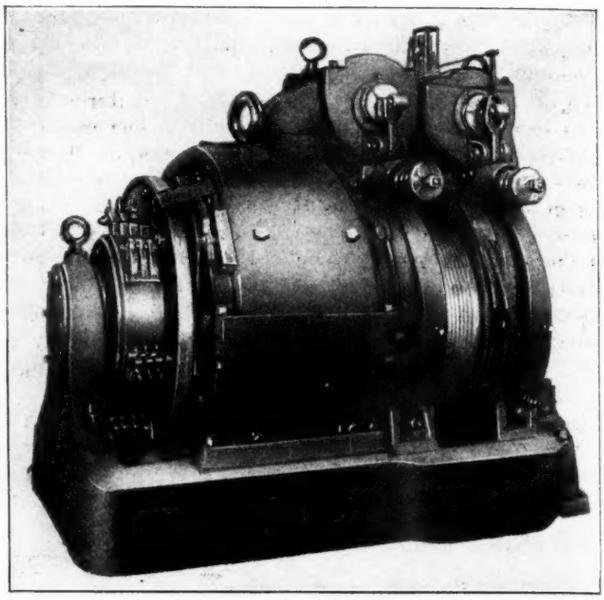


FIG. 6. TRACTION MACHINE WITH TWO BRAKES

In the most modern elevator installations an electro-mechanical type of safety is used on the car and a mechanical type of safety on the counterweights. The details of these safeties are shown in Figs. 7, 8 and 9. Fig. 7 gives the general scheme of roping up the governor to the car and counterweight safeties, Fig. 8 the details of the electro-mechanical safety on the car, and Fig. 9 the counterweight-safety details. A description of the operation of the safeties is as follows:

Starting from the governor G, Fig. 7, the governor rope R is deflected by the two small sheaves at the top of the counterweight so that it leads straight down and around the counterweight-safety sheaves S, Fig. 9, making two full turns, then it is deflected off the counterweight by the two small sheaves at the bottom of the counterweight to the governor-tension sheave B, Fig. 7. The governor-tension sheave at the bottom of the pit is counterweighted, as shown at B in the complete installation, to keep the proper tension on the rope. This sheave is free to move vertically, the movement being controlled by guides in the pit. After leaving the tension sheave, the rope runs up to the car and is deflected by small idlers under the car, Fig. 7, to the car-safety sheave. After making two full turns around the safety sheave S, Fig. 8, the rope is led by idler sheaves to a releasing carrier on top the car and thence back to the governor G, Fig. 7.

During normal operating conditions the safety sheaves *S* remain stationary and the governor rope also remains stationary with respect to the car and counterweight. The motion of the car and counterweights causes the governor rope to rotate the governor *G* and the tension sheave *B*. A releasing carrier on the car prevents motion of the sheaves *S* until a heavy pull on the governor rope releases the carrier. When the governor is rotated above a predetermined speed, the balls of the governor open a switch which controls a magnet whose contacts are in series with the magnet under the car, shown at *A*, Fig. 8. When this magnet is de-energized, the spring *C* causes the jaws *D* to apply a light retarding force on the rails *E* and thus brings the car gradually to a stop.

In case, however, the hoisting ropes part, the downward motion of the car and counterweight causes the governor rope to rotate the safety sheaves *S*, Figs. 8 and 9, and this in turn causes the safety jaws *D* to clamp the rails and stop the car, and the safety jaws *J* to clamp to the counterweight guide rail and stop the counterweight.

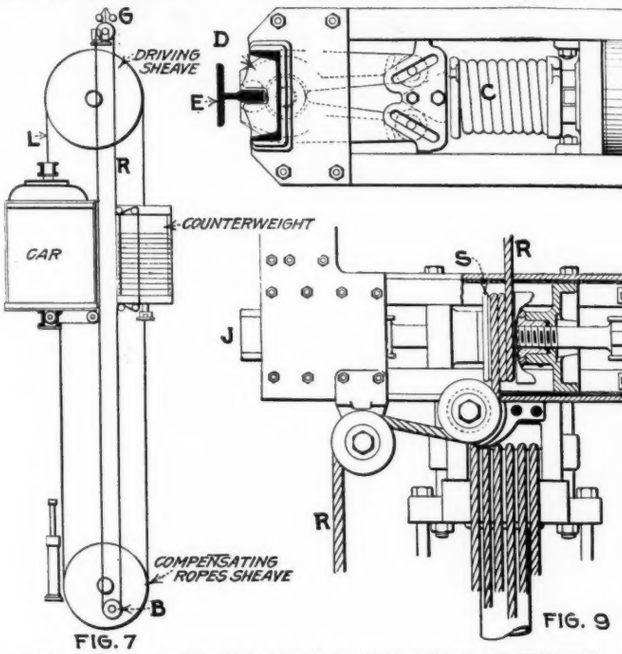


FIG. 7

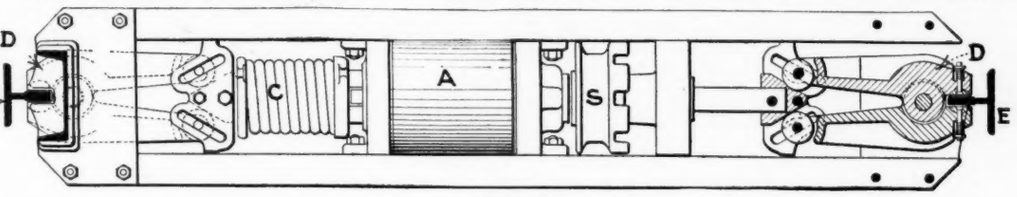


FIG. 8

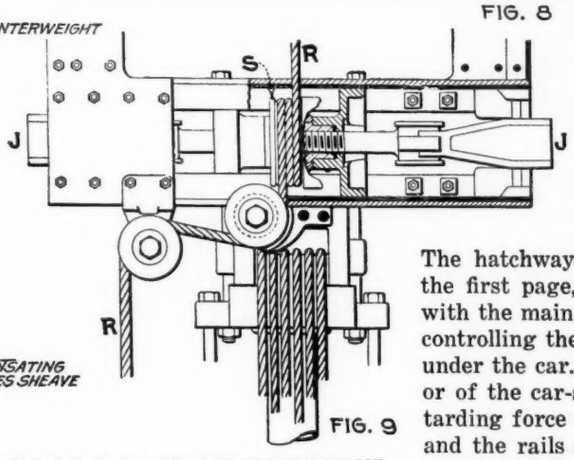


FIG. 9

FIGS. 7 TO 9. DETAILS OF CAR AND COUNTERWEIGHT SAFETIES

The controller panel for the motor is operated by a car switch in the car, under control of the elevator operator. The control-circuit conductors are placed in conduit between the controller and a junction box *J* at the center of the hatch, shown in the complete installation, and flexible cables containing the conductors are provided from this junction box to the bottom of the car platform, where they are led in conduit to the car switch.

The gearless-traction elevator-machine motor is shunt-wound, and its field winding is always excited as long as the line switch is closed. The field connections are made direct to the line so as to eliminate possible opening of the field circuit and overspeeding the motor.

To secure proper control, it is necessary to provide for slow speed and for acceleration to be gradual. For slow speeds it is necessary not only to use resistance in series with the armature, but to use a resistance across the armature, so as to obtain proper speed control. In starting a gearless-traction elevator, the minimum bypass resistance is connected across the armature, and the maximum resistance in series with the armature and bypass resistance. The bypass resistance is increased in steps by the closing of contactors 1, 2, 3 and 4, Fig. 5. When contactor 4 operates, the bypass resistance is opened, leaving only the series resistance in circuit. Contactors 5, 6, 7, 8 and 9 are operated automatically by a single magnet *A* connected across the motor's armature, which is energized by the closing of an auxiliary contact on contactor 4. As the armature comes up to speed, the voltage across it increases; this increases the pull of the magnet, and as the pull increases, contactors 5, 6, 7, 8 and 9 operate successively, each cutting out of circuit a section of the series resistance. When contactor 9 closes, the motor is placed directly across the line. The speed is still further increased by the opening of the fast-speed magnet *F*, which puts a resistance in series with the motor's field. Contactor *M* is the main potential switch and, when closed, connects the line to the contactor panel. When the potential switch is open, its bottom contacts connect a resistance across the motor's armature, which acts as an electrical brake, if the car is in motion, and brings the motor to a dead stop. The hatchway-limit switches *H* in the installation on the first page, and the car-safety switch are in series with the main potential-switch coil and also the magnet controlling the solenoid on the electro-mechanical safety under the car. Opening of the hatchway-limit switches or of the car-safety switch therefore causes a light retarding force to be applied between the car-safety jaws and the rails and also connects a resistance across the armature, consequently the car is quickly brought to rest.

The up-and-down contactors *U* and *D*, Fig. 5, are mechanically interlocked and arranged so that they pass the current through the armature to give proper direction of rotation of the motor. The car switch controls the solenoids on the up-and-down contactors *U* and *D*, the slow-speed magnets 1, 2, 3 and 4 and the fast-speed magnet. The operator is consequently able to run the car at any desired speed.

On the top of the car is an automatic stopping switch *A*, shown in the complete installation. This switch has a number of contacts which are successively opened by movement of the switch arm coming in contact with bent angle irons *D* at the top and bottom of the hatchway, called slowdowns. When the car approaches near to the terminal landing, the roller on the stopping arm comes into contact with the slowdowns and continued motion of the car causes movement of the stopping arm and opening of the contacts in switch *A*. The first contact closes the fast-speed magnet and slows the car down; the second, third and fourth gradually reduce the motor's speed by opening the magnets 4, 3 and 1; and the last contact opens the up or down reversing switch, as the case may be. Further details

of gearless-traction elevator control will be given in a later article.

Summing up, the safety devices of the gearless-traction elevator are as follows:

1. Automatic return of the car switch to an off position.

2. The automatic-stopping switch gradually brings the car to a stop as the top or bottom landings are approached.

3. The hatchway-limit swtches operate if the car continues to move after the automatic stopping switch opens the reversing switches.

4. The switch operated by the centrifugal governor stops the car in case of overspeeding, by causing a light retarding force to be applied between the car-safety jaws and rails and opening the main potential switch.

5. The oil buffers are capable of stopping the car or counterweight at 50 per cent. excess speed without discomfort to passengers.

6. After the car or counterweight strikes the bumpers, the traction between the hoisting cables and driving sheave is either lost or greatly reduced.

7. Overtravel beyond the top terminal landing lifts the compensating sheaves and housing, and this in turn helps to decrease the traction and also operates a switch to stop the motor.

8. Opening of the car-safety switch stops the motor and applies a light retarding force between the car safety jaws and rails, thus stopping the car.

9. For high-lift elevators a mechanical retarding and latching device is provided to stop the car from overrun beyond the top-terminal landing.

10. Breaking of the hoisting ropes causes the application of a heavy retarding force on the car and counterweight safeties.

Proper Packings Produced Savings

By Waldo Weaver

My experience in paper mills and rubber plants has made it apparent that too many engineers are penny wise and dollar foolish in the purchase of packings.

The following will demonstrate my contention: The engines driving the heaters and jordans were invariably shut down two or three times weekly to pack the cutoff-valve stems. As a ten-minute shutdown in a paper mill means a loss of one hour on the paper machines, it is obvious that such shutdowns result in a drop in production, amounting in this case to from $100 to $200 weekly. After trying out several packings, one was secured that made it certain that the engines would not have to be shut down from this cause.

It was also necessary to pack the piston rods every second week so that the engines could be operated continuously from Monday morning to the next Sunday morning. It was a regular Sunday job in our case to slaughter about three boxes of soft coil packing, costing about $21. Metallic packings were applied, which saved the company over $500 the first year. A similar condition existed in a rubber mill with the addition that a shutdown of the main engine resulted in a much greater loss in production and profits. The kind of packings which had been found so satisfactory in the paper mill were purchased and applied.

In this rubber mill there was no end of trouble with the outside-packed power and hydraulic pumps. It was an every Sunday job to pack these pumps, and it cost the company considerable for labor as well as for packing. Various combinations of cut rings were experimented with and finally such combinations selected as gave the longest wear without repacking and did not produce a detrimental wear on the plungers. Some of these pumps were operated for more than a year without repacking. In one instance the pump was not repacked in three years. The life of packings depends on the construction and workmanship of the pump, dust in the surrounding air, etc.

Some years ago I suffered a shutdown in a small central-station plant because of a broken hard-rubber valve in the large boiler-feed pump. As the smaller pump would not hold the water up in the boilers on the peak load and as the large pump could not be put back into service at once because the repairman broke the stud off in removing it, it was necessary to drop nearly half the service. This cured me of that kind of pump valve. I use nothing but special composition valves which, although expensive, are worth the money, as they will outwear four to five sets of the ordinary rubber valves, and besides do not require replacing so often. I have not found brass valves satisfactory.

Care should also be exercised in the selection of pump valves used with condensers. The first cost of such valves can be considerably reduced by using thinner ones; besides, thin valves will wear longer than thick ones as the lift can be made less, also the spring tension.

Considerable slippage results in high-pressure pumps and fire pumps because the valves are too hard. Inside-packed pumps will give much less trouble and the slippage will be less if special solid or uncut duck rings are used. Rock-hard duck should be used on hot water. Valve-stem packings should likewise be given special attention. Shredded metal gives the best results when used in combination with a good grade of soft twist packing. Certain brands of twist packings are far superior to others that are said to be of the same combination. This is especially true where superheated steam is encountered.

Many engineers seem to think the packing on centrifugal pumps requires little attention, yet last winter I witnessed a tremendous loss in a large rubber mill due to this oversight, resulting in the destruction of many quite expensive brass sleeves. Naturally, the labor expense for replacing these sleeves was of far greater importance than the cost of the sleeves. One centrifugal handling 12,000 gal. per min. to a condenser had been in operation about a year, yet the sleeves had grooves worn in them over one-half inch deep. This was also true of a new boiler-feed centrifugal. It was all uncalled for, but the engineers passed it by as only a small thing.

Special attention should be given to the packing of centrifugals used in connection with condensers where the pump lifts its water. This is true even though the glands are water-sealed. In one case the vacuum was increased 1.7 in. by keeping these glands tight on the circulating water pump. The rise in vacuum resulted from increasing the water circulated. The speed of the pump was not augmented.

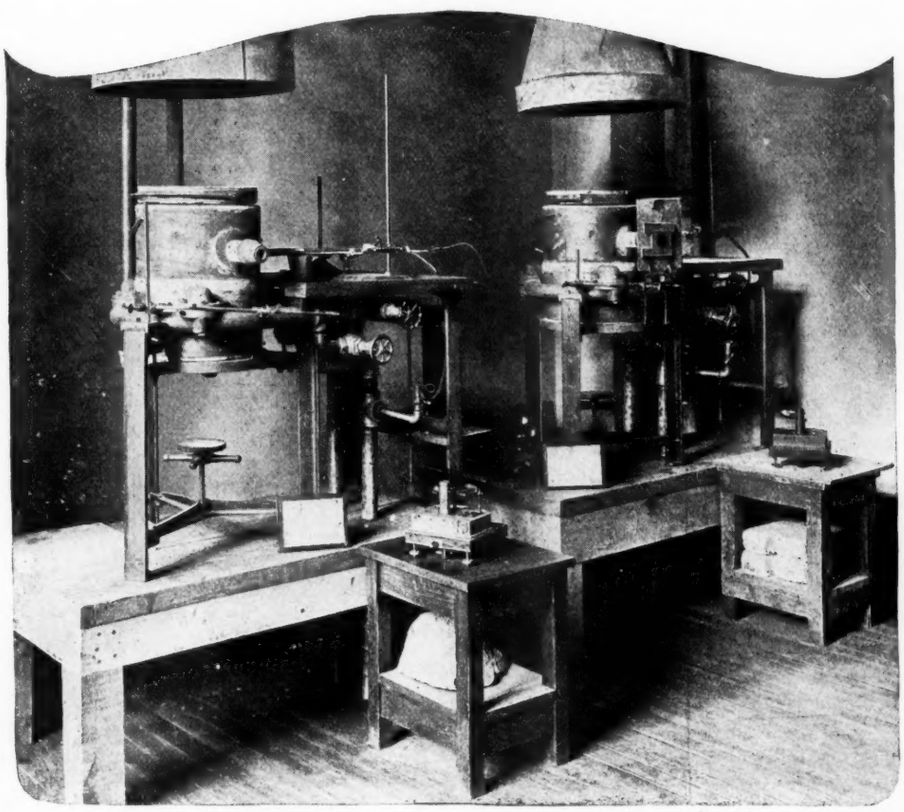
Packings are only one of the many things that require special thought and intelligence and serve to make the engineer either a success or a failure, and will pay the owner good dividends in several ways if given proper attention.

Fusibility of Ash from Great Lakes and Mississippi Valley Coals*

By W. A. SELVIG, W. C. RATLIFF, AND A. C. FIELDNER

Some of the most valuable of the articles on clinkers and the fusion temperatures of ash appearing in "Power" are: "Fusion Temperatures of Ash," by Bailey and Calkins, Nov. 8, 1910; "Fusion Temperatures of Ash," by Wing (discussion of the previously mentioned article), Dec. 27, 1910; Reply to Wing by Bailey, Feb. 7, 1911; "Fusing Temperatures of Coal Ash," Bailey, Nov. 28, 1911; "Clinkering Properties of Coal," Hubley, Dec. 1, 1914; "The Clinkering of Coal," Professor Marks, Dec. 29, 1914; "Cause and Prevention of Clinker," Bureau of Mines, Aug. 31, 1915; "Clinkering of Bituminous Coal," Hubley, a series of four unusually valuable articles, Oct. 10, 17, 24 and Nov. 7, 1916. "Fusibility of Coal Ash from West Virginia Coals," W. A. Selvig, Oct. 15, 1918.

THE Interior coal province which includes all of the bituminous coal fields near the Great Lakes, in the Mississippi Valley, and in Texas, contains a vast amount of coal which is extensively mined and has been an important factor in the development of the manufacturing centers of this region. While there is a large amount of analytical data available as to the composition of these coals[1], there has been no general survey of the fusibility of the ash from the various coal beds comprising this coal province. The Bureau of Mines is making fusibility tests on the well-known American coals, and this paper gives a summary of such tests on the coals of the Interior province. A previous paper[2] of the Bureau of Mines gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash fusibility tests, together with a summary of such tests on West Virginia coals. Analyses of clinkers from boiler furnaces indicated that the conditions were such as to form clinkers in which the iron is present principally in the ferrous state, consequently the values obtained in the laboratory tests are in this respect comparable to the actual fuel-bed conditions, and give the lowest temperatures at which the intimately mixed ash softens with the formation of clinker. The tables of fusibility of coal-ash tests give the average values for all mines tested in each coal bed. Average values for each mine were computed from the individual samples, which in practically all cases are standard mine samples collected by representatives of the Bureau of Mines, the United States Geological Survey, or by the various state geological surveys, accord-



FURNACES USED TO DETERMINE FUSION TEMPERATURES OF ASH

*Abstract of a paper on Fusibility of Coal Ash from the Interior Province Coals as compared with West Virginia Coals. Published by permission of the Director, United States Bureau of Mines.

[1]Lord, N. W., and others, "Analyses of Coals in the United States, with Descriptions of Mine and Field Samples Collected Between July 1, 1904, and June 30, 1910"; Bull. 22, Bureau of Mines, 1913, 1200 pp. (In two parts).

Fieldner, A. C., and others; "Analyses of Mine and Car Samples Collected in the Fiscal Years 1911 to 1913"; Bull. 85, Bureau of Mines, 1914, 444 pp.

Fieldner, A. C., and others; "Analyses of Mine and Car Samples Collected in the Fiscal Years 1913 to 1915"; Bull. 123, Bureau of Mines, 1917, 456 pp.

Parr, S. W.; "Chemical study of Illinois Coals; Illinois State Geological Survey, Coal Mining Investigations"; Bull. 3, 1916, 86 pp.

[2]Selvig, W. A.; "Fusibility of Coal Ash from West Virginia Coals; *Power*, Oct. 15, 1918, p. 566; *Chemical and Metallurgical Engineering*, Vol. 19, No. 12, 1918, p. 826. For a complete table giving results obtained for each mine tested, see: Selvig, W. A.; "Fusibility of Coal Ash from West Virginia Coals"; *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16.

ing to the methods used by the Bureau of Mines[3]. A small number of car samples that were considered representative of the output of the various mines are also included.

The point taken as the softening temperature is that at which the ash when molded into solid triangular pyramids ¾ in. high and ¼ in. wide at the side of the base, and mounted in a vertical position, has fused down to a spherical lump. Points at which the tips of the cones first fuse and at which the ash has become very fluid are also taken and serve mainly as an indication of the viscosity of the melting ash; however, these values are not given in the tables. The average percentage of ash and sulphur, on the dry coal basis, is given as a basis of comparison of the different beds.

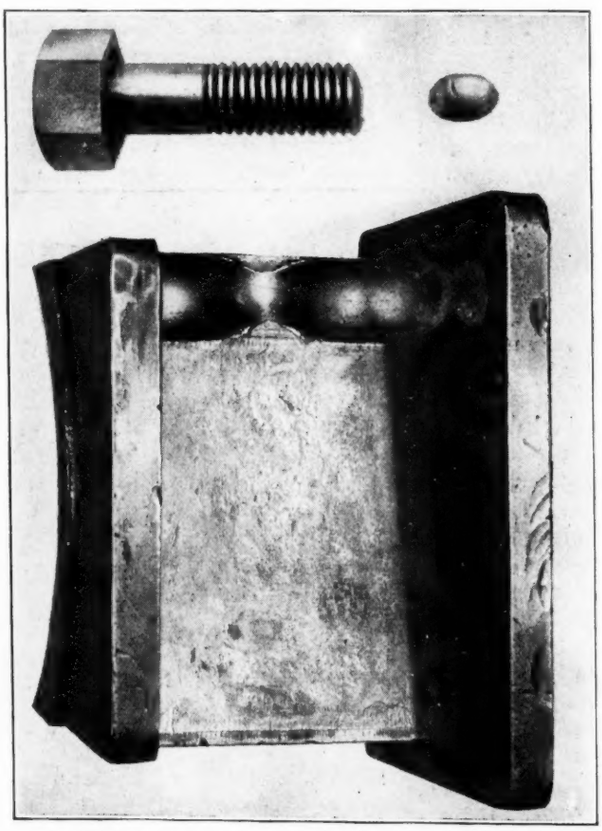
TABLE I. FUSIBILITY OF COAL ASH FROM THE INTERIOR PROVINCE COALS

Region, State, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Deg. F.	Ash in Dry Coal, Average Per Cent.	Sulphur in Dry Coal, Average Per Cent.
1	2	3	4	5	6
Eastern Region:					
Illinois					
No. 1 Bed	1	5	2110	11.74	4.86
No. 2 Bed	6	15	2010	9.97	3.58
No. 5 Bed	9	27	1990	10.84	3.28
No. 6 Bed	36	160	2160	10.27	2.30
No. 7 Bed	2	13	2050	10.62	2.69
Indiana					
No. 3 Bed	3	11	2090	10.61	4.34
No. 4 Bed	7	30	2390	8.17	1.62
No. 5 Bed	9	29	2130	10.23	3.54
No. 6 Bed	1	5	2040	9.91	2.65
Minshall Bed	1	1	2120	9.60	2.99
Western Kentucky					
No. 6 Bed	1		2130	8.81	2.97
No. 9 Bed	20	78	2030	10.53	3.67
No. 10 Bed	2	2	1990	11.99	4.18
No. 11 Bed	7	39	2030	9.57	4.08
No. 12 Bed	3	17	2150	10.20	2.30
Western Region:					
Kansas					
Bevier Bed	2	6	1980	14.83	4.71
Cherokee Bed	3	8	2110	9.42	3.18
Leavenworth Bed	1	3	2020	18.26	5.46
Weir-Pittsburgh Bed	3	7	2010	11.68	5.31
Missouri					
Bevier Bed	16	42	1960	13.47	4.90
Bowen Bed	1	3	1940	13.18	4.61
Cainsville Bed	1	3	1980	12.71	5.78
Cherokee Bed	1	3	2150	7.51	1.97
Jordan Bed	4	12	2010	12.74	4.42
Lexington Bed	14	39	2000	13.48	4.04
Lower Rich Hill Bed	3	8	1940	15.39	5.43
Lower Weir-Pittsburgh Bed	2	6	1940	10.78	4.45
Mulberry Bed	2	5	1990	14.58	3.18
Mulky Bed	4	9	1940	11.28	5.25
Rich Hill Bed	1	3	1970	15.47	6.12
Tebo Bed	8	23	2040	11.64	4.66
Waverly Bed	1	2	2020	17.43	8.29
Oklahoma					
Dawson Bed	3	3	1920	8.95	3.91
Henryetta Bed	2	2	1980	8.03	1.59
Lehigh Coal Bed	3	15	2150	11.46	4.17
Lower Hartshorne Bed	9	27	2020	6.03	1.43
McAlester Bed	6	28	2180	6.94	1.67
McCurtain Bed	1	6	2110	6.92	0.84
Panama Bed	2	4	2160	6.81	1.46
Stigler Bed	5	5	2050	5.13	1.91
Upper Hartshorne Bed	3	7	2170	6.15	1.51
Arkansas					
Denning Bed	1	3	2200	7.38	2.45
Hartshorne Bed	5	9	2120	11.59	1.40
Paris Bed	1	3	2140	10.12	3.28
Shinn Basin Bed	1	1	2180	10.36	2.23
Southwestern Region:					
Texas					
Santo Tomas	2	2	2580	19.21	4.98

What a Broken Wedge Bolt Did

Broken wedge bolts are not uncommon in reciprocating-engine practice, and sometimes the result is somewhat curious. One recent instance was that of an 18 x 36-in. Corliss engine running at 106 r.p.m. 24 hours per day, with the exception of Sunday, when a small engine was used for the necessary light and power during the week-end shutdown.

One morning the chief engineer in making his round noticed that there was an accumulation of brass in the oil pan underneath the crankpin, but the night engineer, on being questioned, disclaimed having had any trouble with a hot brass, and that the engine was running all right was evident. On Sunday, when the engine was shut down, the chief had the crankpin brasses removed. He was surprised to find that two depressions on the back of the brass next to the wedge had been worn, also on either side of the brass flanges. These are shown in the illustration,



CRANKPIN BRASS WORN BY BROKEN WEDGE BOLT

also the broken adjusting bolt; the egg-shaped portion is what is left of the broken-off end of the same bolt.

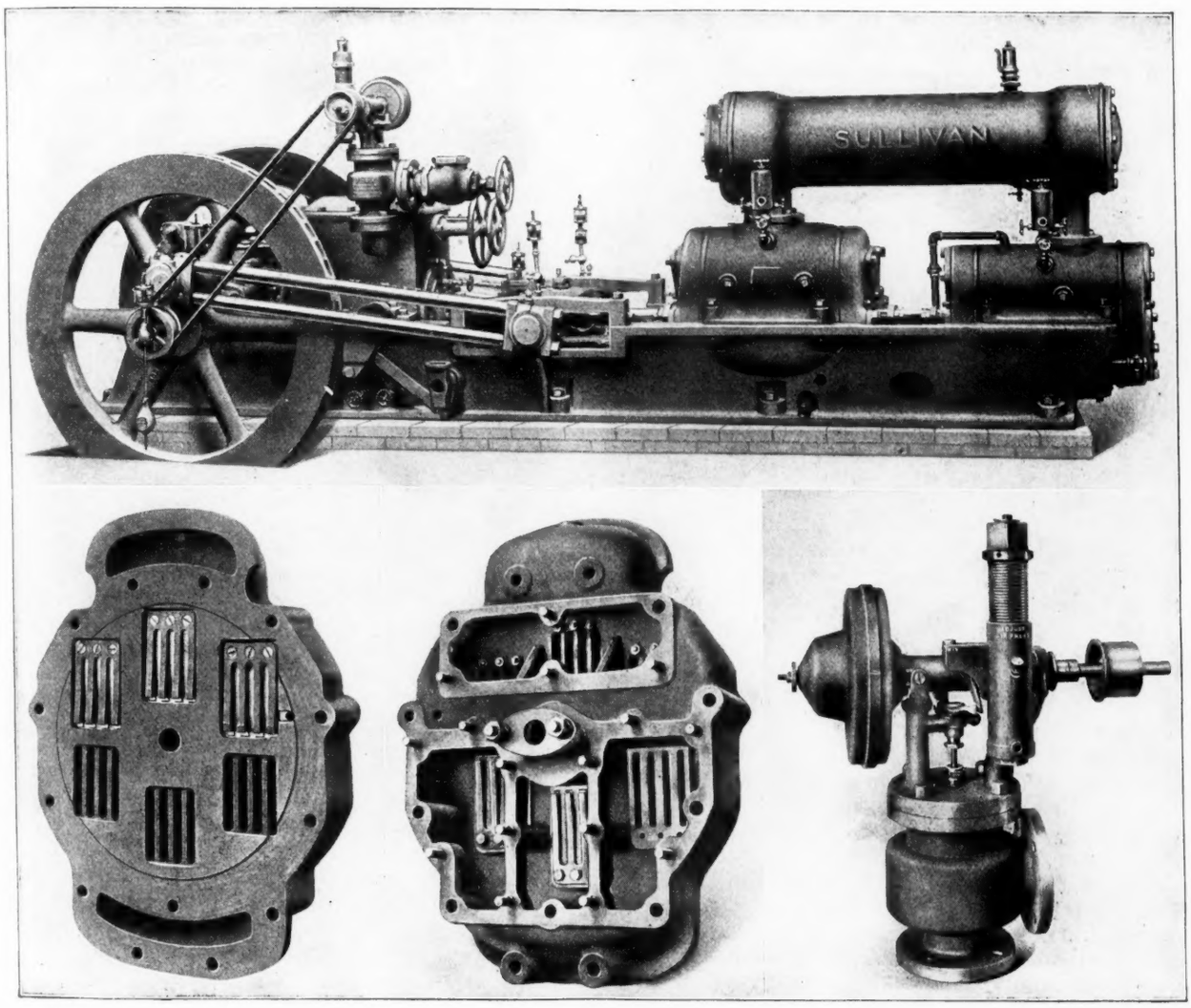
During the night shift the top wedge bolt broke. The engineer took out the longer section of the bolt and managed to remove the broken end from the wedge, but neglected to remove it from the space between the wedge and the top of the crankrod. As there was nothing to prevent putting in a new wedge bolt and adjusting the bearing, this was done and the engine was started up and ran along as usual. The piece of adjusting bolt that was left in the space between the adjusting wedge and the crankrod was about ¾ in. long, and in bouncing back and forth with the throw of the crank it was worn egg-shaped, the threads entirely disappeared and the bearing brass was worn as shown.

Although there is nothing peculiar in the action of this broken wedge bolt, it is a very good example of what constant pounding will do even with a light stroke. The time the broken piece of bolt was being knocked back and forth was about one month.

[3]Holmes, J. A.; "The Sampling of Coal in the Mine"; Technical Paper 1, Bureau of Mines, 1911, 18 pp.

Plate Valves for Sullivan Straight-Line Compressors

During the last year a radical improvement has been made in the design of the Sullivan straight-line steam-driven two-stage air compressor. For the semirotary or Corliss mechanically driven air inlet valves, formerly applied on these machines, the new type of Sullivan plate valves has been substituted. These valves, which are similar in design to those in successful use for the last two years on Sullivan angle-compound compressors, are shown in the illustrations. They are designed to secure rapidity of action, wide port opening with minimum wiredrawing effect and a reduction in the power required to operate them. The loss from clearance and leakage in this design is comparatively low, so that high volumetric efficiency is secured.



SHOWING SULLIVAN STRAIGHT-LINE, TWO-STAGE AIR COMPRESSOR: INSIDE FACE OF CYLINDER HEAD, CYLINDER HEAD WITH VALVE COVERS AND SOME OF VALVES REMOVED, AND COMBINED SPEED AND PRESSURE REGULATOR WITH SAFETY STOP

The finger valve, as it is called, is of a distinctive grid form, shaped like a group of thin flat fingers or blades and made from sheet spring steel. It is bolted at one end only to a steel guard plate, the other end being free. This guard plate is curved to form a rest for the entire length of each blade, when it is bent or lifted by the incoming or outgoing air. In lifting, under air pressure, the fingers exercise a rolling or rocking action against the guard, opening first at their outer end. When closing, the fingers roll back to their seats, the fixed end closing first and the free outer points last. This action eliminates hammering and insures noiseless operation. The valves seat over rectangular ports in the face of the cylinder heads. The inlet valves are situated in the upper half of the head, and the discharge valves, which are of the same design, in the lower half.

Other improvements in the compressor are a simplified steam valve mechanism controlled by a Meyer adjustable cutoff and the Judson type of combined speed and pressure regulator fitted with a safety stop. The speed-controlling element is located at the end of the horizontal shaft shown in the illustration. For protection against dirt it is inclosed in a casing. Three adjustments are provided—maximum speed, minimum speed and air pressure—each of these being independent of the other. Where the demand for air is intermittent, an automatic unloading valve is provided to supplement the action of the governor.

The compressor is built in capacities ranging from 400 to 950 cu.ft. of air per minute.

United States Nitrate Plant No. 2 at Muscle Shoals—Main and House Turbines

By CHARLES H. BROMLEY

This is the first complete description of the triple-cylinder, pure-reaction parallel-flow turbine to be published. The Muscle Shoals machine, which is the most interesting of this new type, is of 60,000-kw. continuous capacity. Its flexibility of control is one of its paramount features. Performance data are given and the sequences of operations of control and signal systems are explained.

THIS is the second of a number of articles treating of this interesting power plant. The main turbine unit is of the reaction, cross-compound, triple-cylinder parallell-flow type. While there is similarity between this 70,000-kw. maximum unit and the latest machine installed in the Seventy-Fourth Street Station, New York City, the former is perhaps the most interesting turbine. As the triple-cylinder or compound-type unit has had to date only meager description, it is fitting that the machine be quite fully described here. The writer is appreciative of the cooperation of the purchasers, the Air Nitrates Corporation, and the builders, the Westinghouse Electric and Manufacturing Co.

The turbine installation consists of a single unit having a capacity of 60,000 kw. continuous and a maximum of 70,000 kw. for short periods. It consists of a single-flow high-pressure turbine operating at 1800 r.p.m., and two semi-double-flow low-pressure turbines operating at 1200 r.p.m., and three generators of equal capacity. The turbine is of the pure-reaction three-cylinder 88-stage type. It is designed to divide the load equally between the three generators at 60,000 kw. The overall dimensions are: Length, 53 ft. 8 in.; width, 56 ft. 2 in.; height, 19 ft. 3 in. The shipping weight is 2,600,000 lb., and the heaviest piece for the crane is 142,000 lb. Fig. 1 shows an end elevation of the machine.

Steam at 275-lb. pressure and 175 deg. F. superheat is admitted to the single-flow high-pressure element through two 18-in. steam headers, each equipped with an 18-in. combination throttle valve. These are united into a 26-in. inlet, entering the turbine through a governor-controlled, oil-relay-operated, double-balanced poppet valve. Steam strainers are provided in each of the 18-in. headers. In emergency either one of these headers may be taken out of service without affecting the operation of the unit except to reduce its maximum capacity to about 50,000 kw. The exhaust from the high-pressure turbine is divided equally between the two low-pressure turbines. The receiver pressure, which varies almost directly with the load, is 62 lb. abs. at 60,000 kw. The inlet to each low-pressure is 32 in. in diameter and is provided with a gate valve and an automatically controlled butterfly valve so arranged that when the valves are closed either high-pressure or low-pressure turbine may be entirely dismantled while the other is in operation. These receiver pipes are supported on springs, a detail of which is shown in Fig. 1, thus relieving the turbines of stresses other than those caused by temperature changes, though most of these latter are cared for by the expansion joint. The butterfly valves may be operated automatically or manually.

There is an atmospheric relief connection to the bottom of the high-pressure turbine adjusted to open when the receiver pressure reaches aproximately 80 lb. abs. This valve protects the receiver pipe against excessive back pressure in case of one or both of the automatic butterfly valves on the low-pressure turbines closing. It also protects the low-pressure turbines against excesive load in case the high-pressure turbine is automatically cut out of service and the low-pressure turbines operated on high-pressure steam.. There is also an atmospheric relief valve on the exhaust from each of the low-pressure turbines to protect the condensers and exhaust piping against excessive pressure should the condensers, for any reason, fail.

Each low-pressure turbine is provided with a 14-in. high-pressure steam supply under governor control. It is, therefore, practicable to operate either of the three turbine elements alone on high-pressure steam or to operate the high-pressure turbine together with either one of the two low-pressure turbines.

The high-pressure turbine is provided with an overspeed governor to close the two 18-in. main throttle valves and the governor controlled inlet valve in case of overspeed. Each low-pressure turbine is similarly equipped with an overspeed governor which closes the butterfly valve in the 32-in. low-pressure steam-supply line and also the 14-in. throttle valve in the high-pressure steam supply. Either of these overspeed mechanisms may be quickly tripped by hand. This provides a means of almost instantly shutting off all steam supplied to either turbine element.

The high-pressure element is small and made almost entirely of steel on account of the high temperatures and pressures involved. The blades are large and strong and their velocities low. The steam velocities are only about one-third higher than those of the blades, thus reducing the steam-friction losses to a minimum and preventing erosion. In the high-pressure element the smallest blades are 4 in. high by 1 in. nominal width while the largest are 9 in. high by 1¼ in. in width. In the low-pressure elements the shortest blades are 4 in. high by ½ in. nominal width, and the largest 18 in. high by 1¾ in. in width. The low-pressure blading is relatively lighter than the high-pressure because of the lesser steam densities.

The total expansion from throttle pressure to condenser pressure is divided into 88 stages or pressure drops, 44 of these taking place in the high-pressure element and an equal number in the low-pressure elements. The turbine is designed for highest efficiency at 50,000 kw., which load is carried on the primary valve. Overload capacities of 60,000 kw. and 70,000 kw. are obtained by means of bypassing a few of the high-pressure stages by means of secondary and tertiary overload valves, shown in Fig. 3. At 50,000 kw. the secondary valve begins to open; and at 60,000 the ter-

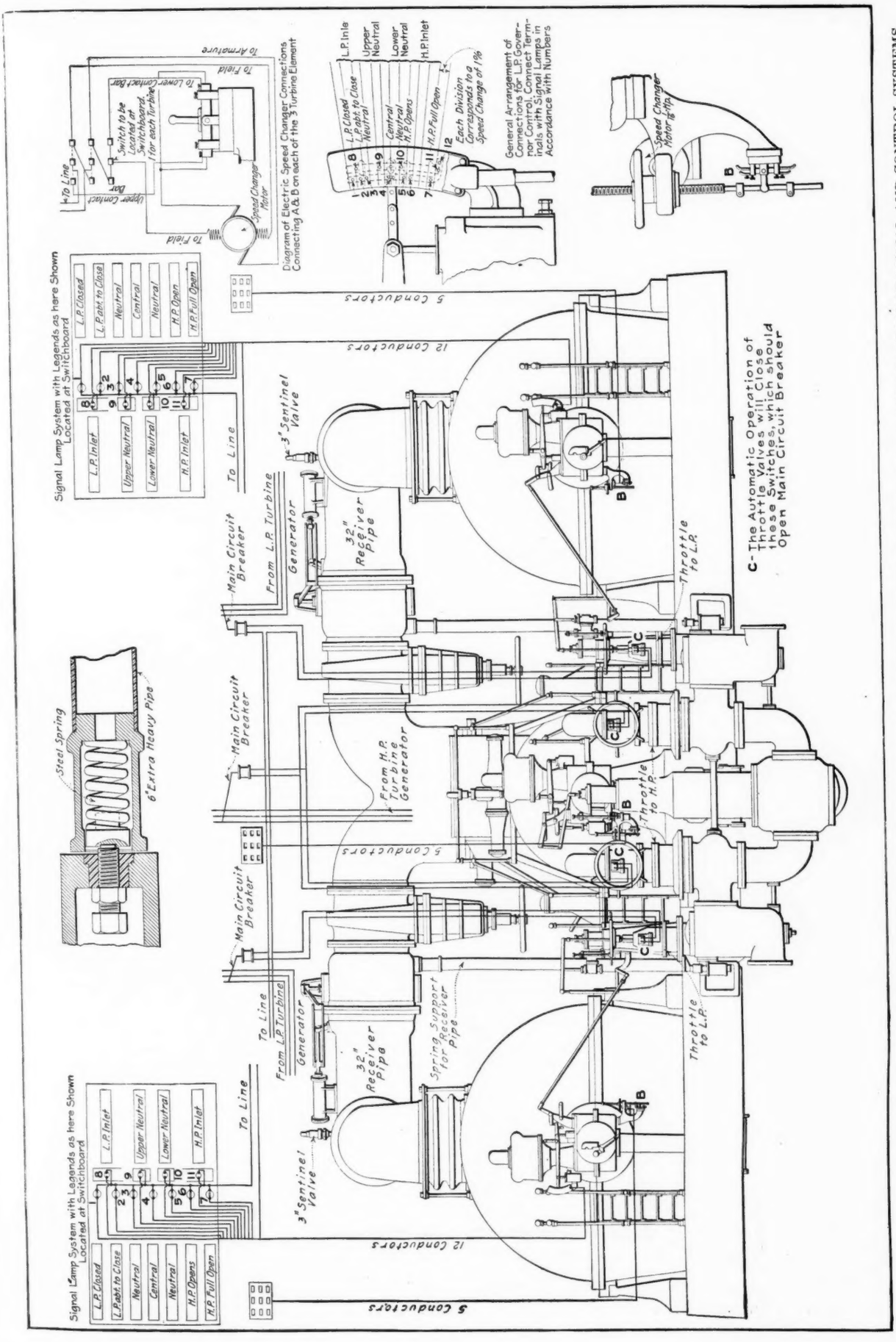

Signal Lamp System with Legends as here Shown Located at Switchboard
L.P. Closed
L.P. Abt. to Close
Neutral
Central
Neutral
H.P. Opens
H.P. Full Open
L.P. Inlet
Upper Neutral
Lower Neutral
H.P. Inlet
To Line
From L.P. Turbine
Generator
Main Circuit Breaker
3" Sentinel Valve
32" Receiver Pipe
Spring Support for Receiver Pipe
From H.P. Turbine Generator
Throttle to L.P.
Throttle to H.P.
12 Conductors
5 Conductors
Steel Spring
6" Extra Heavy Pipe
Diagram of Electric Speed Changer Connections Connecting A & B on each of the 3 Turbine Element
To Armature
To Field
To Lower Contact Bar
Switch to be Located at Switchboard. 1 for each Turbine
Upper Contact Bar
To Line
Speed Changer Motor
General Arrangement of Connections for L.P. Governor Control. Connect Terminals with Signal Lamps in Accordance with Numbers
Each Division Corresponds to a Speed Change of 1%
C- The Automatic Operation of Throttle Valves will Close these Switches, which should Open Main Circuit Breaker

FIG. 1. END ELEVATION OF 60,000-KW. COMPOUND TURBINE, SHOWING DETAIL RECEIVER-PIPE SUPPORT AND WIRING DIAGRAM OF SIGNAL AND CONTROL SYSTEMS

tiary begins to leave its seat; the primary valve is wide open at about 53,000 kw., while at 70,000 kw. all valves are wide open. The turbine cylinders are carried on separate supports or chairs, as nearly as possible on a level with the horizontal center line. To maintain proper alignment independent of cylinder temperatures, such as occasioned by varying loads and vacuum, and to permit free expansion of the cylinder without distortion, the large exhaust chambers of the low-pressure turbines particularly are heavily ribbed and braced to secure adequate rigidity and maintain proper clearances and alignment under extreme fluctuations of temperature and vacuum. The turbine foundation during construction is shown in Fig. 2.

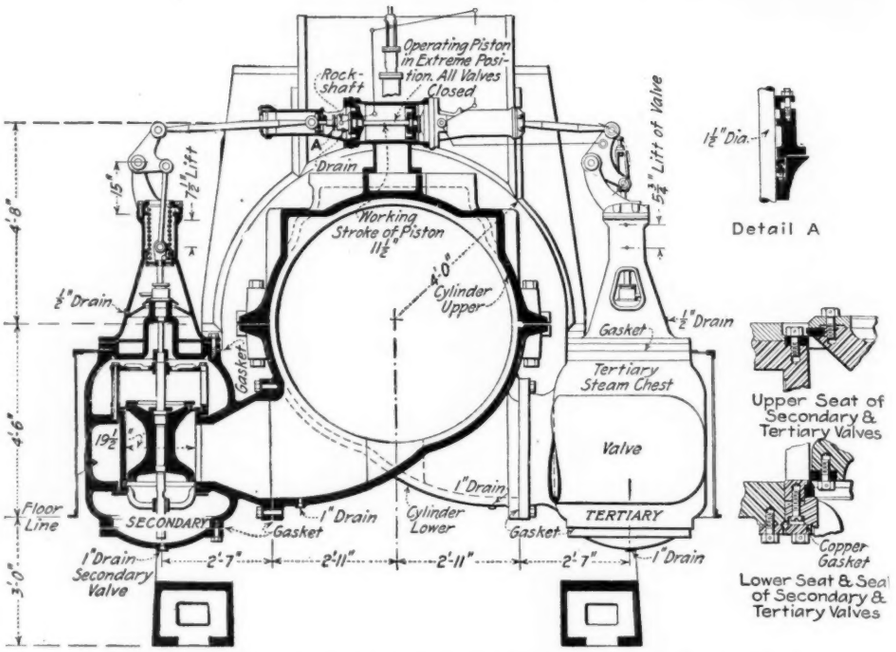


FIG. 3. ARRANGEMENT OF SECONDARY AND TERTIARY VALVES

At 50,000 kw. the secondary begins to open and at 60,000 kw. the tertiary leaves its seat; the primary is full open at 53,000 kw. and at 70,000 kw. all three valves are wide open.

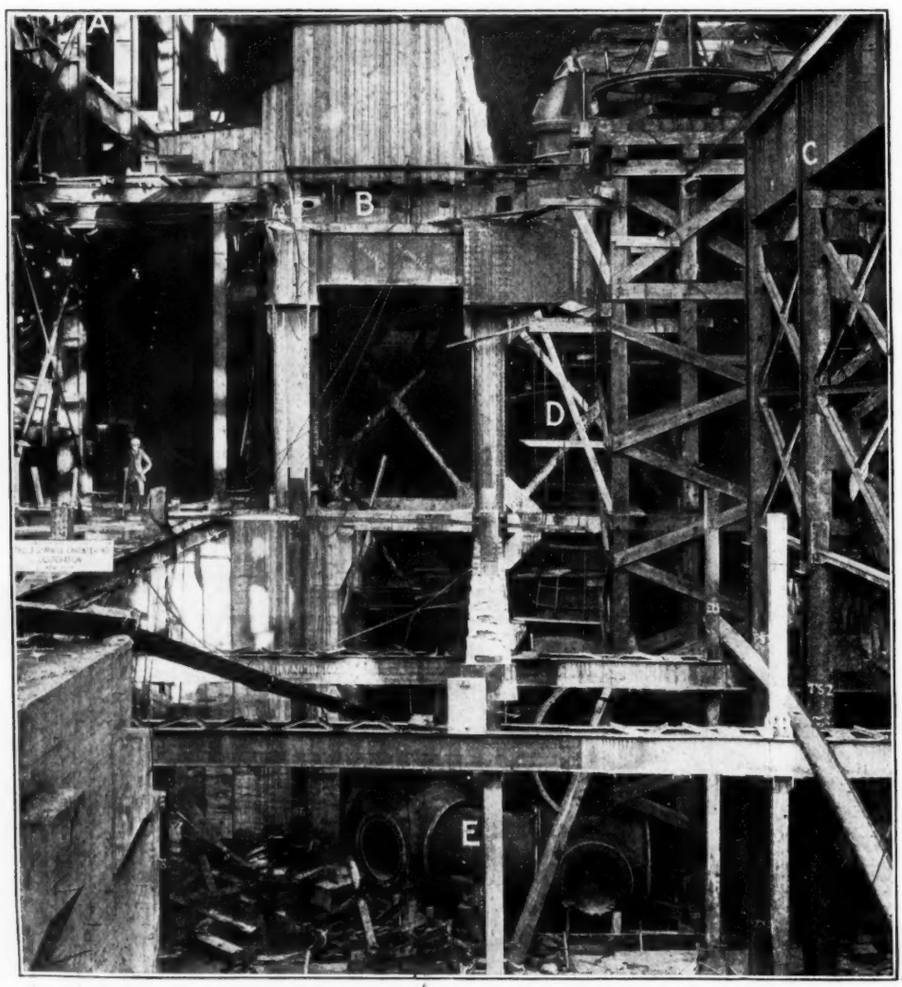


FIG. 2. VIEW OF TURBINE FOUNDATIONS DURING CONSTRUCTION

Locate the man at the left to get an idea of the magnitude of this work. *A*, electrical galleries; *B*, bedplate; *C*, house-turbine foundation; *D*, exhaust connection; *E*, 60-in. pipe.

Clean and tight seals between turbine cylinder and rotating shaft are secured by means of combination steam labyrinth and water glands. In the high-pressure turbine, where the steam pressure on the inside of the cylinder is high, the steam labyrinth is continually in service; a leak-off to the low-pressure being provided between the steam labyrinth and the water gland, the water gland simply preventing leakage of steam to the atmosphere or leakage of air into the leak-off. On the low-pressure turbine the glands seal only against vacuum. The water glands only are normally in service. The steam labyrinth is employed to permit establishing vacuum on the condensers while starting. An essential feature is that with both the steam labyrinth and water glands there is no mechanical contact between the rotating and stationary elements, and consequently practically no deterioration.

Each turbine element is equipped with a reciprocating-type oil pump, Fig. 4, geared from the main rotor. Each pump is provided with doubled opposed plungers and delivers oil from two discharge openings at differ-

ent pressures. The high-pressure side has a plunger 3¼ in. in diameter and pumps against 60 lb. pressure with a capacity of 29½ gal. per min. The low-pressure side has a 4-in. diameter plunger pumping against 5 to 8 lb. pressure, with a capacity of 44.8 gal. per min. The oiling system, Fig. 5, is arranged so that normally the three pumps discharge into common high-pressure and low-pressure systems. Provision is made, however, for easily cutting out of service either pump, or the oil supply to either turbine element. The high-pressure discharge leads directly into the surge tank from which all the oil-operated governor valves are supplied. The low-pressure discharges lead directly into the oil coolers, together with the high-pressure oil which has either passed through the oil relay operating cylinders, or the spring-loaded bypass valves. From the coolers the oil

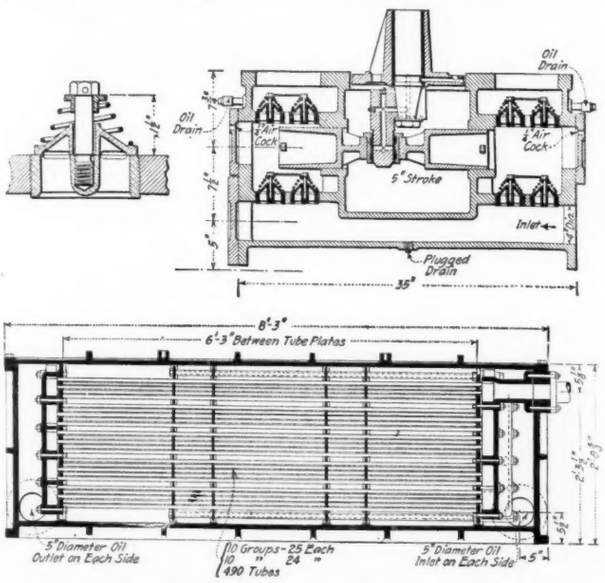


FIG. 4. OIL PUMP AND COOLER, 60,000-KW. TURBINE

Each turbine element has one of these reciprocating pumps in parallel discharging into common high- and low-pressure systems. Each high-pressure plunger delivers 29.5 gal. per min. against 60 lb. pressure; each low-pressure plunger, 44.8 gal. per min. against 5 to 8 lb. Oil coolers: Two used; totaling cooling surface, sq. ft., 1200. Each cooler has 490 brass, 0.75-in. tubes in 10 groups of 25 each and 10 groups of 24 each, baffled to give 5 passes; water passes serially through tubes, making total of 20 passes.

is distributed to the bearings, thence back to the reservoir through the strainer.

A diagrammatic layout of the oiling system is shown in Fig. 5; it is quite self-explanatory. The oil strainer or filter has capacity for 1500 gal. per hr. and the reservoir a much larger capacity. The oil cooler, shown in section in Fig. 4, has been designed with a view to giving excellent performance even after having been in service for a long period without cleaning; that is, there is a liberal cooling area. There are 490 brass tubes ¾-in. diameter No. 18 B.w.g., 6 ft. 3 in. long between tube sheets, giving 600 sq.ft. total cooling surface, baffled to give five passes and assembled in 10 groups of 25 tubes each, and 10 groups of 24 each. The cooling water passes serially through each group, making a total of 20 passes. There are two such coolers. The oil overflow and vent box, shown in section in Fig. 6, indicate the quantity of oil in the system and provide an automatic means of discharging from the system oil taken from the bottom of the reservoir equal in quantity to the fresh oil added, thus enabling continuous operation of a partial filtration system without dependence of operation of the turbine on the satisfactory operation of the filtering system with respect to the quantity of the oil supply. There are two oil coolers, Fig. 4, normally operated in parallel, but so piped that either one may be taken out of service for cleaning without disturbing the operation of the system, the arangement of valves being such that it is impossible to shut off the oil supply to the bearings by improper manipulation of the valves. The hotwell water, of which there is about 200,000 lb. per hour and which is at a temperature varying from 68 deg. F. to 100 deg. F., assists in cooling the oil supply. The oil imparts heat enough to the water to increase its temperature to about 130 deg. F. The automatic control system permits either turbine element being automatically or manually cut out of service without disturbing the operation of the other two elements. The main generator busses are divided into three sections, joined only by reactance coils. Each section of bus is energized by one of the three generators, circuit-breakers being provided between the generator and the bus section. In case of a heavy short-circuit on a section of the bus or the feeders leading from it, the circuit-breaker between that section and the generator supplying it will open. In case the circuit-breaker opens on either of

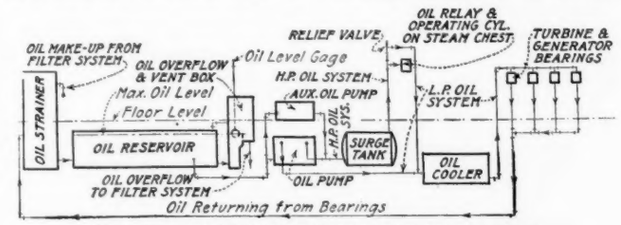


FIG. 5. DIAGRAM OF THE OILING SYSTEM

Filter capacity 1500 gal. per hr.; normal circulation of oil through each bearing of main turbine, in gal. per min.: high-pressure, 10; low-pressure, 12.5; thrust bearing, 20. Total oil-cooler surface, 1200 sq.ft. Hotwell water used to cool the oil. Unit load on bearings, lb. per sq.in.: High-pressure, 80; low-pressure, 124.

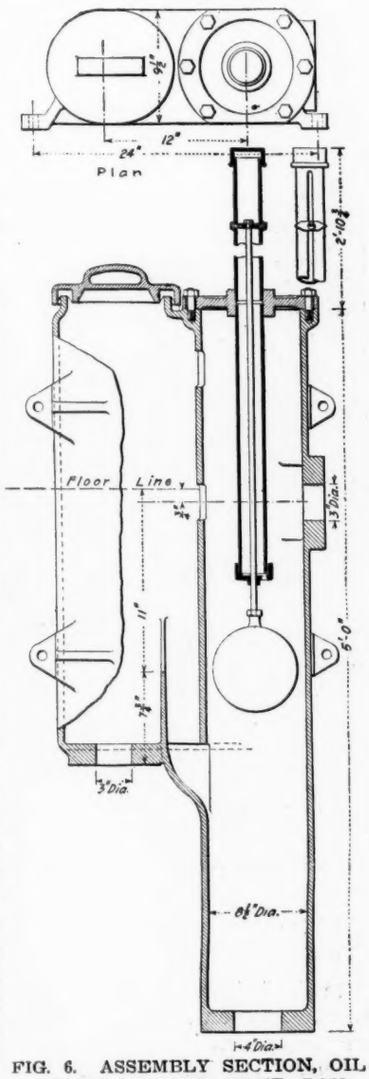


FIG. 6. ASSEMBLY SECTION, OIL OVERFLOW AND VENT BOX

Indicates the amount of oil in the system and provides automatic means of discharging from the system oil taken from the bottom of the reservoir equal in quantity to fresh oil added, making possible continuous operation of turbine on partial filtration system.

the low-pressure turbines, the turbine will quickly increase in speed approximately 3 to 5 per cent., at which point the governor will close the automatic butterfly valve in the low-pressure steam-supply line. The turbine will then slow down until a speed 2 to 3 per cent. below normal is reached, at which point the governor will open the high-pressure inlet valve and admit sufficient high-pressure steam direct from the boilers to keep the turbine operating at that speed. As soon as the trouble is remedied, the switchboard operator, by means of the electric speed changer, can bring the turbine up to normal speed, synchronize it and close the circuit-breaker. The operating engineer must, however, manually close the gate valve in the receiver line, open and reset the automatic butterfly valve and then open the gate valve to put load on the turbine. If the circuit-breaker on the high-pressure opens, it will increase in speed approximately 2 per cent. and remain there under control of its governor. The two low-pressure turbines, being deprived of steam, will cease to carry load. The speed and frequency will therefore drop approximately 3 to 5 per cent., at which point the high-pressure governor valves on the low-pressure turbines will open, and the low-pressure turbines will carry their full rated load on the high-pressure steam. The switchboard operator can immediately readjust his governors to give normal frequency. As soon as the electrical trouble has been corrected, the high-pressure turbine can be synchronized, its circuit-breaker closed and, by adjustment of the speed changers on the three governors, the whole unit restored to normal operation without any assistance from the operating engineer or the manipulation of any valves.

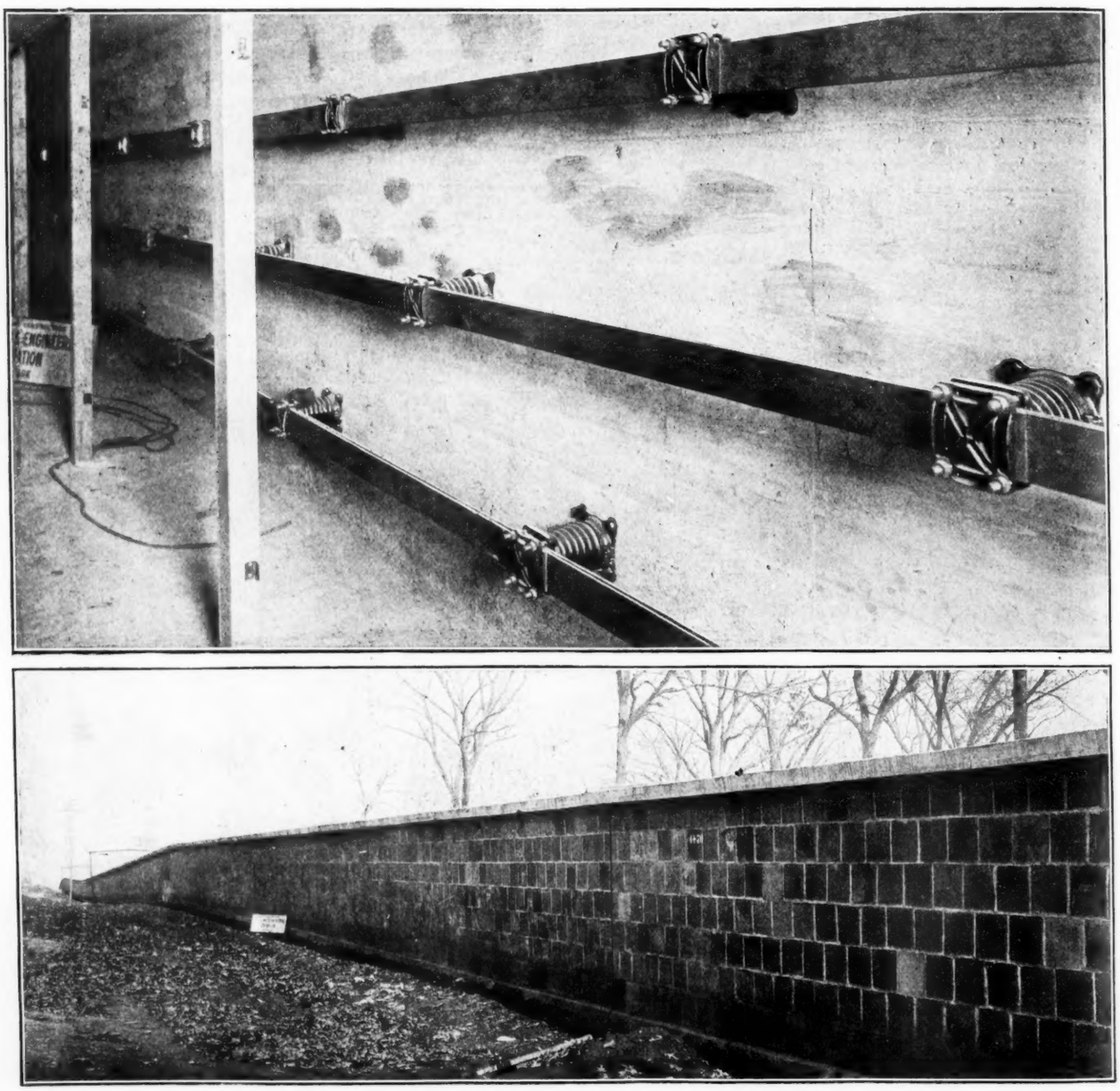


FIG. 7. INTERIOR AND EXTERIOR VIEWS OF THE BUS TUNNEL

Made of tile brick and concrete, 4000 ft. long, current at 12,000 volts is transmitted from the power house to the switch house, where it is distributed. Open transmission line would be too seriously affected by carbide dust from the cyanamid mill.

If the automatic governing mechanism on either low-pressure turbine operates either manually or automatically, the butterfly valve supplying it with steam from the high-pressure turbine and the 14-in. throttle valve supplying it with high-pressure steam will both close, and the circuit-breaker between the generator and its bus section will open, permitting the turbine to come to rest. If the automatic on the high-pressure turbine is tripped, only the two 18-in. high-pressure throttle valves and the main governor-controlled inlet valve will be closed, and the turbine will come to rest. The low-pressure turbines will reduce in speed about 3 to 5 per cent., and then will automatically take high-pressure steam sufficient to carry the load, the governors being quickly adjusted to bring the speed and frequency up to normal.

The automatic signal system keeps the switchboard operator fully informed as to the conditions under which each element is operating and enables him to maintain the proper adjustment of each of the three governors.

The floating lever of each low-pressure governor has a projecting arm which moves across 12 electric contacts closing lamp circuits, the lamps indicating the position of each low-pressure governor. A diagram of these connections is shown in Fig. 1. The operation of these throttles will close these switches and open the main circuit-breaker. But should the circuit-breaker on any one element open, the control system will maintain control of this element and keep the other two elements in service. In the event of injury to one of the three elements and the release of the automatic stop—each element has a safety stop—the circuit-breaker of the particular element will be opened and the element cut out, the other elements remaining in service. The safety stop on each machine is capable of closing its own automatic throttle valve and other steam admissions to that element.

During normal operation the switchboard operator maintains both low-pressure turbine governors in approximately central position. The high-pressure turbine governor is adjusted to fine regulation; but the low-pressure governors are to have not less than three times the speed variation of the high-pressure governor because the governors have three operating conditions, explained a few paragraphs farther on.

This installation is provided with a double set of busses, a sectionalized bus as previously referred to, and also a solid bus. With the sectionalized bus connected to the system, which may already be energized by other units, the circuit-breakers connecting the three generators to the solid bus are closed; the condensing equipment put into operation; steam seals turned on to the low-pressure glands; and a vacuum established on the low-pressure turbines; the auxiliary oil pumps started; the fields of the main generators excited; and either one of the two high-pressure throttles opened sufficiently to start reduction of the high-pressure element. The two low-pressure elements will immediately rotate in synchronism by reason of the field charges. After suitable warming up at slow speed, the unit is gradually brought up to speed and the solid bus synchronized with the sectionalized bus. The three circuit-breakers between the generators and the sectionalized bus are then closed and the breakers between the solid bus and the generators opened. The second high-pressure throttle valve may be opened at any time after the unit has been brought up to normal speed, and before the load exceeds approximately 40,000 kw.

The governors on the two low-pressure elements differ somewhat from that on the high-pressure element, although in mechanical construction the three are almost identical. The high-pressure governor has but one function to perform: that is, to control the opening of the valves admitting steam to the high-pressure turbine. It is therefore arranged to operate throughout its whole travel on a speed variation of approximately 4 per cent.

Each low-pressure governor has its travel divided into three parts and is adjusted to require a 12 per cent. change in speed to operate it over its full range of travel. The lower third of this travel is employed to control the opening of the high-pressure steam valve. The middle third is a neutral zone in which the governor operates idly when all three turbine elements are operating as a combined unit. The upper third is employed to close the butterfly valve controlling the low-pressure steam supply to this element in case its circuit-breaker opens.

The operating conditions are 275 lb. gage steam pressure, 200 deg. superheat and 29 in. vacuum. These figures are higher than those upon which the original guarantee was based, as they were predicated upon 275 lb. gage pressure, 175 deg. F. superheat and 28.5 in. vacuum. For these latter conditions the following performance is guaranteed.

Load in Kilowatts	29-In. Vacuum	28.5 In. Vacuum
	Pounds Steam per Kw.-Hr.	
30,000	11.05	11.55
40,000	10.75	11.15
50,000	10.55	10.90
60,000	10.75	11.10
When operating the high- and one low-pressure side:		
30,000	12.1	12.45
When operating one low-pressure element or high-pressure steam:		
20,000	14.0	14.45

Should the steam pressure be increased at the throttle to 300 lb. abs. (285 lb. gage) with 185 deg. F. superheat, the performance guarantees will be reduced 1.2 per cent.; increasing the pressure to 315 lb. abs. (300 lb. gage) with 185 deg. F. superheat, the guarantees will be reduced 1⅜ per cent.

The peripheral speed of the last row of blades in each low-pressure element is 513 ft. per sec. mean, 555 ft. per sec. tip.

Excitation for the high-pressure generator is furnished by a 90-kw. generator and for the low-pressure machines by a 115-kw. generator; the voltage for each is 240.

Four 25,000-sq.ft. condensers, each having 5285 one-inch Muntz metal tubes 18 ft. 3⅜ in. long, are used. The steam-inlet openings of the condensers are 30.5 ft. below the exhaust openings of the turbines. Particulars relative to these condensers, their supports, pumps, intakes, etc., are treated of in another article following this one.

There are four 44,000 gal. per min. circulating pumps, four dry vacuum pumps, four condensate pumps, water pump for cooling the oil, and three blowers for cooling the generators. The above include spares.

A table giving all the important weights, dimensions, speeds, pressures, areas, volumes, loads, velocities and capacities relative to the turbine and condensers—the whole station, in fact—appeared in the first article dealing with this station published in *Power*, Mar. 25, 1919.

For furnishing current for auxiliaries and other uses in the station two 2000-kw. pure-reaction single-flow turbines have been installed; the high-pressure ends of the cylinders are of cast steel. These ma-

chines are each of 2500 kv.-a. at 80 per cent. power factor, 60 cycle three-phase 2300 volt. They will operate at 275 lb. pressure, 175 deg. F. superheat, noncondensing, against a back pressure of 5 lb. gage. Their over-all length is 24 ft. 5 in., width 9 ft. 10 in., height 6 ft. 10 in.; the total weight is 81,000 lb., the heaviest piece for the crane being 9000 lb.

Their performance (80 per cent. power factor) is as follows:

Load, Kw.	Water Rate per Kw.Hr.
1,200	28.1
1,600	25.5
2,000	26.6

One air washer with a capacity of 8000 cu.ft. per min. is provided for each machine, the washers each being driven by a 5-hp. motor and having a pumping capacity of 60 gal. per min.

To obtain high thermal efficiency of the station the noncondensing house turbines drive all auxiliaries, which are motor-driven (except the boiler feed pumps), the amount of exhaust steam used for heating feedwater being regulated to suit station load conditions.

Heat balance studies of the station form the subject of another article which will appear in an early issue.

Fig. 7 shows an interior and exterior view of the bus tunnel used to contain the copper transmission busses connecting the power station with the switchhouse 4000 ft. away. An open transmission system would be too seriously affected by the carbide dust and lime dust.

Boiler Explosion at Paso Robles, California

By P. HANSEN

A HORIZONTAL return-tubular boiler but two years old and tested when new to a pressure of 187 lb. exploded recently at the Natural Soda Products Co. at Keeler on Owens Lake, Calif. The boiler was 18 ft. long and about 6 ft. in diameter. Oil was used for fuel. The usual pressure carried was 100 to 115 lb. The safety valve was set to blow off at 123 lb. pressure and operated with a blowdown to about 110 pounds.

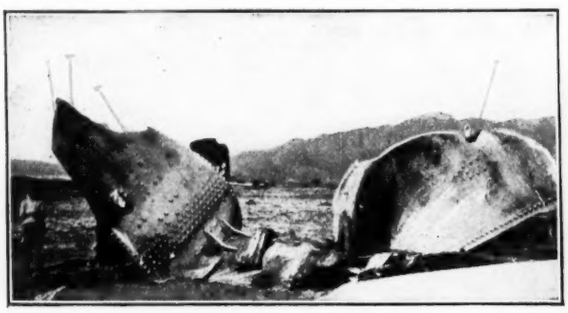


FIG. 1. SHOWING THE REAR PLATE AND END OF THE BOILER

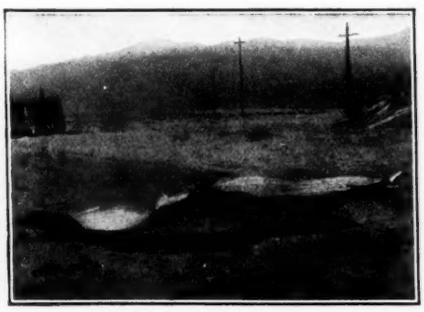


FIG. 2. CENTER PLATE AFTER 490-FT. FLIGHT

FIG. 3. ANOTHER VIEW OF FIG. 1

Steam was used for heating water in the carbonating tanks, blowing out clogged valves, etc. The quantity used was very irregular; for an hour or more at times practically none was required, and then again all the steam that the boiler could possibly produce was used.

The boiler was operated 24 hours a day and 7 days a week. The feed water contained a large amount of inorganic impurities and was fed cold to the boiler. It was the practice to blow some water out twice each twelve-hour shift.

The explosion occurred at 1 a.m. The fireman had come on duty at midnight. He was badly injured and died a few hours later.

The boiler consisted of three plates, each 6 ft. in length. The center one, at a point over the furnace, was torn lengthwise of the boiler. The plate was also torn away from the rest of the boiler, straightened out and thrown a distance of 490 ft. At some parts the

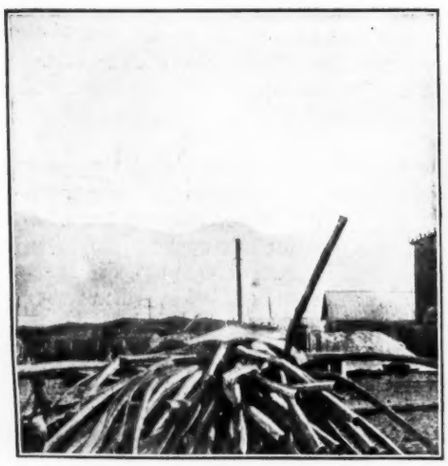


FIG. 4. TUBES AND FRONT HEAD

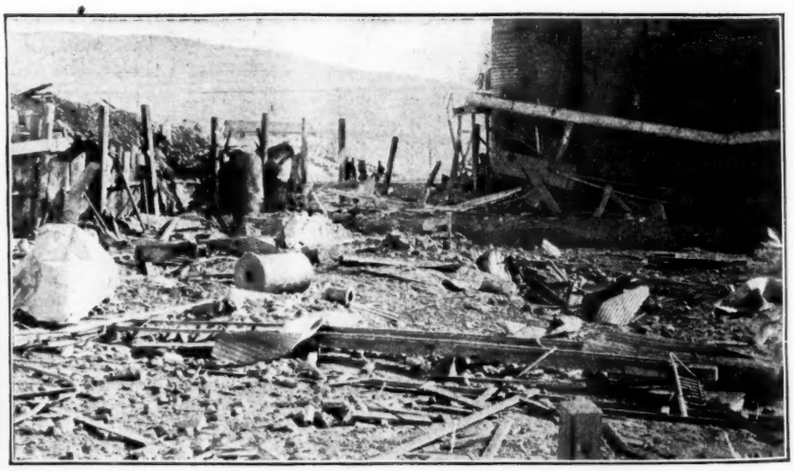


FIG. 5. WHERE THE BOILER HOUSE ONCE STOOD

plate was torn close to the girth seam, elsewhere the tear was in the seam, the rivets being pulled apart. The edges of the plate in the tear which was over the fire were drawn very thin and smooth, showing that the plate had been very hot. After the explosion the hard scale adhering to the plate, about two feet up from the rupture, was fully one-eighth in. thick; the scale farther down and over the furnace had doubtless been much thicker, but it was broken off by the explosions. The explosions were heard with an interval of about one-half minute, the second explosion being the louder.

It is the opinion of some that the scale prevented the water from coming in contact with the boiler plates over the furnace; the plates therefore became overheated and gave way under the high pressure. Another reason may have been that with the plate sagging the scale loosened and the water reaching the overheated plate and suddenly cooling it caused the rupture, and this sudden opening reacted with excessive pressure on all parts of the boiler, tearing it to pieces.

Fig. 1 shows the rear plate and the back end of the boiler with stays, etc.; this was thrown 470 ft. This plate was also torn at the bottom with sharp edges similar to those that were found on the center plate. All other tears have rough edges, showing the grain of the steel. Fig. 2 shows the center plate as it lay after its flight of 490 ft.

Fig. 3 is another view of the head and plate shown in Fig. 1, but from a different point and shows the head and braces. The front plate and head with all the tubes were blown 150 ft. and are shown in Fig. 4. The boiler house stood three feet behind the coke pile shown in the background.

Fig. 5 shows the ground occupied by the boiler house. The brickwork in the center marks the remains of the boiler setting. The building was about 26 ft. long, 24 ft. wide, 25 ft. high and was built of heavy timbers and corrugated iron. Fortunately, the force of the explosion was away from the main plant, otherwise there might have been considerable loss of life and much more damage to the plant. The timbers of the boiler house were smashed to matchwood and scattered over a wide area. Bricks were thrown about 600 ft. in all directions, going through the roofs of buildings, etc. Luckily very few men were at work that night, and excepting the fireman but one man was injured.

The Electrical Study Course—Fundamental Principle of Three-Wire Generators

Gives a brief description of the actual connections of a three-wire generator and its accessories, and then goes on to a discussion of the fundamentals underlying the theory of operation, in preparation for a more extended description.

BALANCER sets are the most convenient means of providing a three-wire system where a source of voltage for the outside wires is available from a separate service or when the unbalanced current required for the system is small. However, there are conditions where it is preferable to use a so-called three-wire generator. This type of machine has come

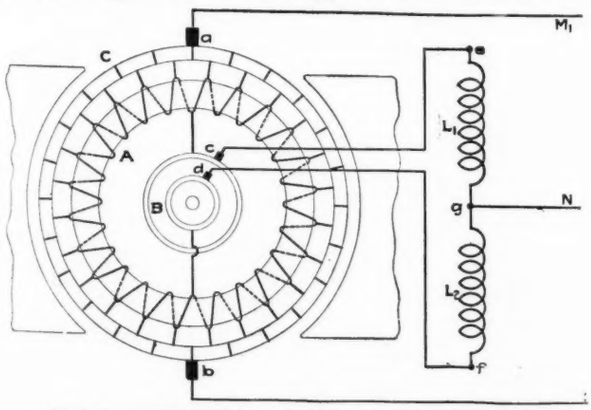


FIG. 1. SCHEMATIC DIAGRAM OF THREE-WIRE GENERATOR

to supplant the combination of two generators in series that was originally used in three-wire installations.

The three-wire generator is an ordinary direct-current generator, excepting that in addition to having a commutator its armature is also provided with slip rings that are connected to the armature winding in the same manner as would be those of an alternating-current generator. The connections between the windings, commutator and the slip rings and the connections of the machine to a three-wire system may be represented as in Fig. 1. The armature winding is represented by *A*, the commutator by *C*, and the slip rings

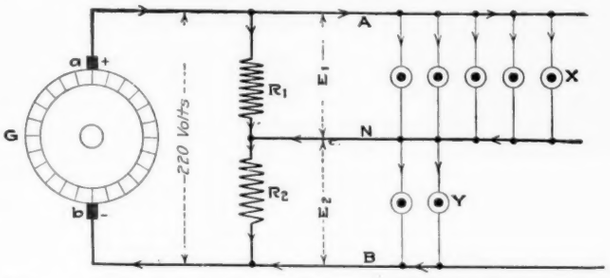


FIG. 2. THREE-WIRE SYSTEM WITH UNBALANCED LOAD

by *B*. The brushes *a b* on the commutator are connected to the outside wires M_1 and M_2 of the three-wire system, and the brushes *c d* on the slip rings are connected to the ends *e f* of two equal inductances L_1 and L_2 connected in series. The mid-point *g* of these inductances is connected to the neutral *N* of the three-wire system. This diagram is rather involved, therefore we shall not attempt to base the explanation on it, but use the simpler diagrams, Figs. 2 and 3. Such a treatment will also give us an opportunity of investigating what inductances are and the reason for their application in the present case.

First of all, suppose we have a system such as that represented in Fig. 2. It will be seen that it is like that of a three-wire system using a balancer set except for the fact that the balancer machines have been supplanted by the resistances R_1 and R_2. Assume that *G* is a 220-volt generator and the resistance of R_1 and R_2 is equal but of very low value, for example, 0.1 ohm. Consider what the voltages E_1 and E_2 across *A N* and

N B, respectively, will be for various conditions of loading represented by the groups of lamps X and Y. Supposing that the lamps used have each a resistance of 100 ohms, what would be the value of E_1 and of E_2 if there were five lamps lighted at X and two at Y?

The joint resistance R_X of the five lamps in group X is equal to the resistance of one lamp divided by the number of lamps, or in this case $R_X = \frac{100}{5} = 20$ ohms. The joint resistance R_Y of group Y is $R_Y = \frac{100}{2} = 50$ ohms. Let R_A equal the joint resistance of the group of lamps X and the resistance R_1 then $R_A = \frac{1}{\frac{1}{R_1} + \frac{1}{R_X}}$ $= \frac{1}{\frac{1}{0.1} + \frac{1}{20}} = 0.0995$ ohm; that is, the joint resistance of all circuits connected between A and N is equal to 0.0995 ohm. If we let R_B equal the joint resistance of R_2 and lamp group Y, then $R_B = \frac{1}{\frac{1}{R_2} + \frac{1}{R_Y}} = \frac{1}{\frac{1}{0.1} + \frac{1}{50}}$ $= 0.0998$ ohm. Then the total resistance between A and B equals $R = R_A + R_B = 0.0995 + 0.0998 = 0.1993$ ohm, and the total current $I = \frac{E}{R} = \frac{220}{0.1993} = 1103.9$ amperes. Then the volts across A and N are $E_1 = R_A I = 0.0995 \times 1103.9 = 109.8$, and the volts across N and B are $E_2 = R_B I = 0.0998 \times 1103.9 = 110.2$. From this it is seen that the value of E_1 and E_2 is quite close to what they should be in a three-wire system, namely, 110 volts.

Let us take a case where the unbalancing is more serious; for example, one in which there are 100 lamps at X and none at Y, Fig. 3. We now have $R_X = \frac{100}{100} = 1$ ohm and $R_A = \frac{1}{\frac{1}{R_1} + \frac{1}{R_X}} = \frac{1}{\frac{1}{0.1} + \frac{1}{1}} = 0.09091$ ohm. Also since there are no lamps at Y we have $R_B = R_2 = 0.1$ ohm. The total resistance $R = R_A + R_B = 0.09091 + 0.1 = 0.19091$ ohm. Then $I = \frac{E}{R} = \frac{220}{0.19091} = 1152.4$ amperes, which gives $E_1 = R_A I = 0.09091 \times 1152.4 = 104.76$ volts and $E_2 = R_B I = 0.1 \times 1152.37 = 115.24$ volts.

In this case the voltages E_1 and E_2 are about five volts lower and higher than they should be, but even that difference is not very serious. It will be found that it is only when the difference between the number of lamps across X and Y is great that the discrepancy in the voltages E_1 and E_2 becomes objectionable. That is, if the resistance of X is low—as it will be if it contains many lamps in multiple—as compared to Y, then E_1 will be considerably lower than E_2. Just how much lower depends upon the resistance of R_1 and R_2. If these are very low, the difference will not be very great, but the nearer the value of R_1 and R_2 approaches that of X or Y the greater will be the difference between E_1 and E_2. It should be understood that when the number of lamps in Y exceeds that in X the same reasoning holds true except that E_2 will in that case be the lower voltage.

From the foregoing it is evident that Fig. 2 really represents a three-wire system wnere the resistance of R_1 and R_2 is low as compared with that of the load on the system. Such an arrangement would, however, never be used, since it would be enormously wasteful of energy. The current through R_1 and R_2 alone, without any lamps being turned on, would be equal to $\frac{220}{R_1 + R_2} = \frac{220}{0.1 + 0.1} = 1100$ amperes, which is of course prohibitive. If, however, some means could be devised by which R_1 and R_2 would throttle down the current that the generator G tries to send through them and yet provide a path of low resistance for any unbalanced current that might tend to flow from N through R_1 or R_2 to A or B respectively, it would be possible to use it in place of a balancer set.

Considering again the conditions in Fig. 3, the current through R_1 is $I_1 = \frac{E_1}{R_1} = \frac{104.76}{0.1} = 1047.6$ amperes and the current in R_2 is $I_2 = \frac{E_2}{R_2} = \frac{115.24}{0.1} = 1152.4$ amperes.

The difference between the current through R_2 and R_1 is 1152.4 — 1047.6 = 104.8 amperes, which is the value of the current in the neutral. That is, R_2 carries the unbalanced current, which is, however, only a small part of the current that it takes itself. Consequently, if we could throttle the latter without impeding the

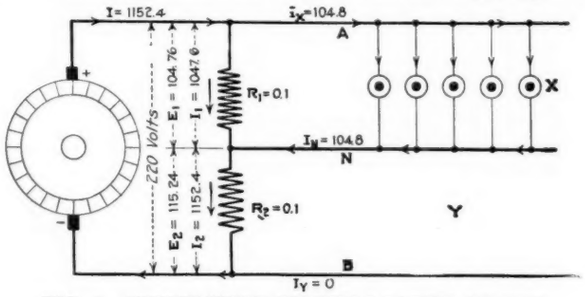


FIG. 3. THREE-WIRE SYSTEM LOADED ON ONE SIDE ONLY

former, we would, as before stated, have the same result as with a balancer set.

By using inductances such as L_1 and L_2 in Fig. 1 in place of the resistances R_1 and R_2 as in Fig. 2 and by connecting the inductances to the brushes c d instead of to a b as the resistances are connected, we are able to accomplish the apparently impossible proposal of limiting one current while allowing free passage to the other. The explanation of this method will follow in the subsequent lessons.

In the preceding problem it was stated that a 220-volt generator rated at 455 amperes was used to supply current to a 110- to 220-volt system. It was required to find how many 40-watt lamps could be operated on the system under these conditions. Since the generator is rated at 220 volts and 455 amperes, its capacity is $220 \times 455 = 100{,}100$ watts. If each lamp takes 40 watts, the number of lamps that can be operated will be $\frac{100{,}100}{40} = 2502$. It was further required to determine the number of lamps that could be operated if the system had to carry a motor load amounting to 60 hp. The motor load in horsepower multiplied by 746 would be its equivalent in watts, or power required for motors equals $60 \times 746 = 44{,}760$ watts. This subtracted from the generator capacity would give the amount of power available for lighting, or

power for lamps equals 100,100 — 44,760 = 55,340 watts. The number of 40-watt lamps that could be used would therefore be $\frac{55,340}{40} = 1384$. In addition to the foregoing it was also required to determine the size of the neutral wire required in the latter case. Assuming that the system might be entirely unbalanced, we know that the neutral wire must be capable of carrying as much current as the outside wires. The current in the outside wires is that required by the lamps connected between them and the neutral, and the number of lamps on each side is half the total number on the system. In the present example the total number is 1384, hence the number of lamps on each side of the system is $1384 \times \frac{1}{2} = 692$. Each of these takes 40 watts at 110 volts, making the maximum load per side $40 \times 692 = 27,680$ watts, which, divided by the voltage, gives the current for each outside wire, namely, $\frac{27,680}{110} = 252$ amperes. Since the neutral is to be of a capacity to carry the current taken by the lamps on one side of the line, it must be large enough to take care of 252 amperes. From the table of carrying capacity of wires we find that if rubber-covered wire is to be used, the size conductor required is 300,000 circular mils and that if the other insulation is used the wire must be No. 000.

In Fig. 2 if there are 50 lamps across X and 30 across Y and each has a resistance of 150 ohms, and the rheostats R_1 and R_2 each has a resistance of 0.5 ohm, what will be the values of E_1 and E_2? What capacity would the generator G have to be to carry such a load?

Test of Liberty Engine

Some remarkably interesting results were obtained in a heat-balance test on a standard high-compression Army-type engine as recently conducted at McCook's Field, Dayton, Ohio. During the test the engine was run at a constant speed of 1600 r.p.m., with the throttle wide open. The average horsepower developed under these conditions was 372.5. The conditions throughout the test were maintained constant and the length of the test was one hour.

The gasoline used had a gravity of 68 deg. Baumé and the average consumption of fuel was 0.492 lb. per hp.-hr. The amount of jacket water pumped was 90 gal. per min., the inlet and outlet temperatures being 150 deg. and 170 deg. F. respectively.

Taking the heat value of the fuel as 19,000 B.t.u. per lb. and assuming 100 per cent. efficiency of the engine, the 183 lb. of gasoline per hour required to produce the average horsepower developed would theoretically have produced 1365 hp. From the results of the test this power was distributed as shown in the acompanying table. The table indicates that 27.3 per cent. of the theoretical horsepower was transformed into useful power for the engine, and that 3.5 per cent. was lost in friction. The loss of heat through the exhaust gases was 44.4 per cent., which is unusually high, while the heat absorbed by the jacket water is lower than usual, being only 24.8 per cent.

HEAT BALANCE OF STANDARD TWELVE-CYLINDER LIBERTY ENGINE

	Horsepower	Per Cent. of Brake Horsepower	Per Cent. of Total
Average brake horsepower	372	100	27.3
Average heat absorbed by jacket water	339	91	24.8
Average friction horsepower	48	13	3.5
Carried off by exhaust gases	606	...	44.4
Total	1,365		100 0

The Value of Yard Screenings

By W. H. Wakeman

The following figures are the results of a test made with a return-tubular boiler to determine the value of yard screenings of anthracite mixed with a small proportion of bituminous coal:

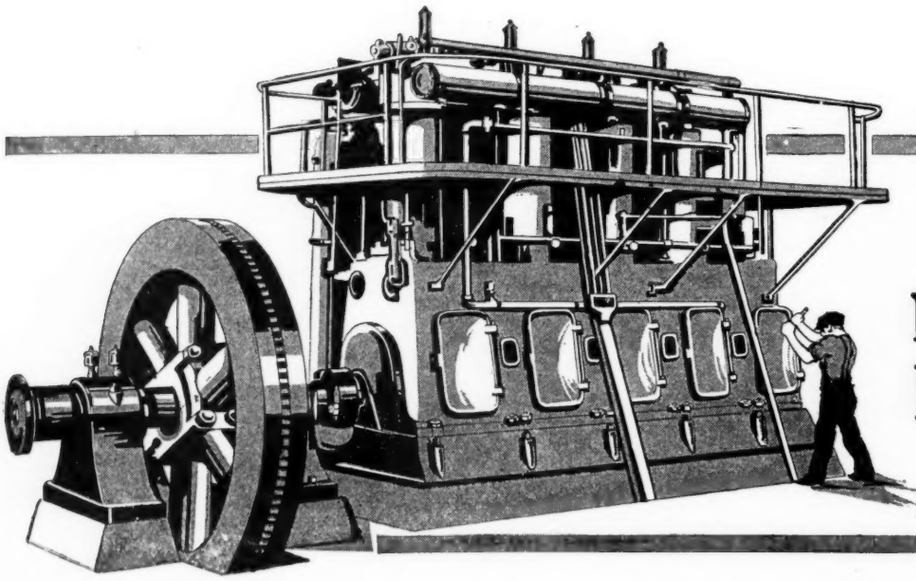
Diameter of shell, in	66
Length of shell, ft	15
Number of tubes	96
Diameter of tubes, in	3
Length of tubes, ft	15
Total length of tubes, ft	1,440
Heating surface in one-half of shell, sq.ft	129
Heating surface in tubes, sq.ft. (1440 ÷ 1.37)	1,051
Heating surface in one head, sq.ft	26
Total heating surface, sq.ft	1,206
Nominal horsepower	100
Grate surface, sq.ft. (5½ x 5½)	30.20
Ratio of grate to heating surface	1 to 40
Grate ¾-in. air space, ¾-in. iron.	
Estimated air space, per cent	40
Balanced draft supplied by blower.	
Steam supplied through ¾-in. steam pipe.	
Power used to operate blower, hp	3
Draft observed from 0.18 to 0.4 inch of water.	
Latest improved type of draft gage.	
Duration of test, hours	16
Steam pressure, lb	75
Temperature of feedwater, deg. F	200
Quality of steam	Dry
Yard screenings, lb	6,210
Bituminous coal, lb	1,555
Total, lb	7,765
Less 4 per cent. moisture, lb	310
Net weight, lb	7,455
Proportion	4 to 1
Coal per hour, lb	466
Coal per hour, sq.ft. grate surface per hour, lb	15.4
Coal per horsepower-hour, lb	3.67
Weight of ash and unburned coal, lb	1,559
Weight of combustible, lb	5,896
Proportion, per cent	21
Water by meter, cu.ft	1,061
Plus 2 per cent., cu.ft	21
Weight per cubic foot (203 deg.), lb	60
Total weight, lb	64,920
Water evaporated per pound of dry coal, lb	8.71
Water evaporated per pound of combustible, lb	11
Water evaporated per hour, 16 hours, lb	4,058
Water per horsepower, lb	32
Power developed for 16 hours, hp	126.8
Water evaporated in 15 hours, lb	63,342
Water evaparated per hour, lb	4,223
Power developed for 15 hours, hp	132

The bituminous coal was screened and nothing larger than about ⅜ in. was used. Care was taken to mix it thoroughly with the screenings. It was well wet down before using. This mixture of coal cost $5 per gross ton, whereas bituminous coal was $10 per gross ton at the time of the test.

The water meter was calibrated by running 5 cu.ft. through it into a barrel. Temperature 200 deg. F. Weight per cubic foot, 60 lb. The meter was adjusted until 5 cu.ft. weighed 293 lb., therefore the meter was 2 per cent. light.

It will be noticed that the water evaporated in 16 hours is 4058 lb. per hour and the amount evaporated in 15 hours is 4223 lb. per hour, also that the power developed in 16 hours was 126.8 hp. as compared with 132 hp. for 15 hours. The following explanation will make this apparent discrepancy in coal consumption and boiler horsepower developed plain.

During the test readings of the meter were taken every hour approximately. These readings showed a considerable variation in the power developed. At the end of 15 hours the boiler had averaged 132 hp. There was a considerable heat in the furnace at that time, more than there was at the beginning of the test. In order to utilize this heat and make a fair test, the fire was allowed to burn for another hour, thus raising the evaporation per pound of coal burned, although there was no way of telling how much coal was burned during the last hour, therefore only the average per hour could be given. Of course the power developed during the last hour fell off sharply, thus lowering the average from 132 hp. for 15 hours, to 126.8 hp. for the 16-hour run.



Talks on DIESEL Engines

by L. H. Morrison

XII—After a day of trouble with the fuel pump, the chief's talk naturally turns to the construction of fuel pumps and their operation.

THE DAY had been full of bad luck and hard work at the Diesel plant, and so the chief was rather surprised when all the day force showed up for the night's meeting.

"Our talk tonight will be pretty pat, after the trouble we had today with the fuel pump," he remarked.

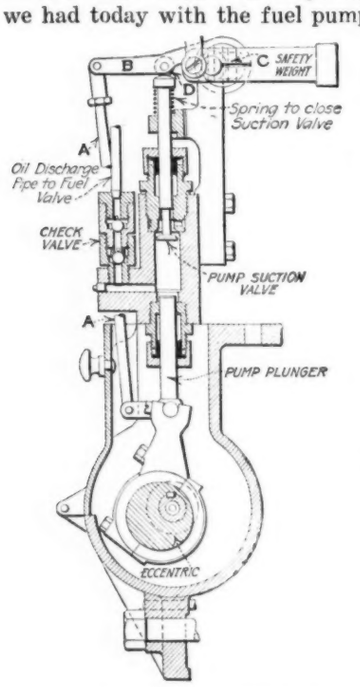


FIG. 1. FUEL PUMP OF AMERICAN DIESEL ENGINE

The men smiled significantly, for the trouble had been a poser for Egan, with all his years of experience.

"There are two classes of fuel-injection pumps for Diesels," he began. "In one the amount of fuel injected is regulated by controlling the closing of the suction valve of the pump. In the other the stroke of the pump is changed to alter the fuel charge."

A puzzled frown had appeared on Woods' face as the chief proceeded. Now he spoke up.

"But it seems to me I've seen a sort of by-pass arrangement to govern the fuel charge."

"You're right," smiled Egan. "My classification was a bit narrow, perhaps. Some makers bypass a part of the oil to regulate the amount of the charge and others use a hollow plunger with a sleeve cutoff valve; but both are simply variations of the controlled suction valve type.

"Since you all were broken in on the old American Diesel, we'll take up its fuel pump first. Fig. 1 shows a cross-section of the pump. The pump plunger is driven by the eccentric, which also gives motion through the rod *A* to the lever *B*. This lever is fulcrumed on the eccentric *C*, which may be turned by the rise or fall of the governor balls. The turning of the eccentric *C* alters the height of the roller *D* that bears against the suction-valve stem and so determines the point at which the suction valve will close when the lever *A* is moving upward. This upward move-

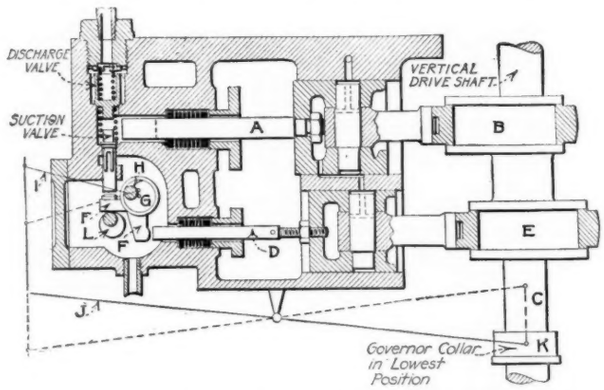


FIG. 2. FUEL PUMP OF BUSCH-SULZER DIESEL ENGINE

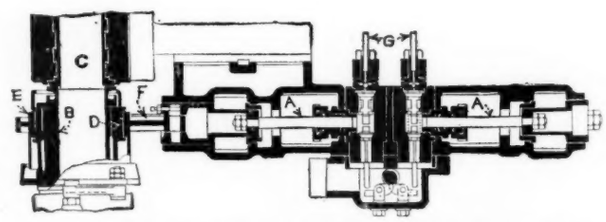


FIG. 3. FUEL PUMP OF McINTOSH & SEYMOUR DIESEL ENGINE

In the next article the chief will talk about governors and governor troubles after announcing the cheering news of an increase of pay.

ment is made on the discharge stroke of the pump plunger.

"This pump is not positively geared to the crankshaft of the engine, but between the pump and the engine is a clutch pinion that allows the pump to be operated by hand in starting. The disadvantage is that the pump may be stopped at the wrong point. It should always be in such a position that the plunger delivers oil when

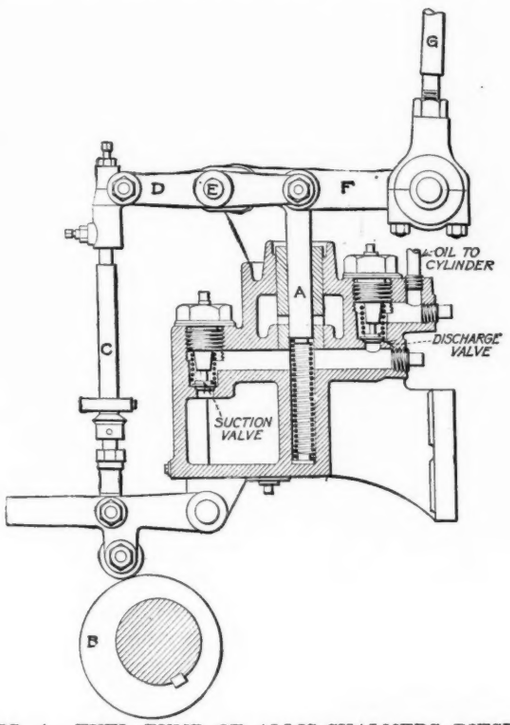


FIG. 4. FUEL PUMP OF ALLIS-CHALMERS DIESEL ENGINE

the piston is on its suction stroke. This gives the fuel time to reach the atomizer before injection begins.

"The discharge valves are ball valves and the smallest particle under the ball will cause it to leak. If a leak occurs, ream the valve seat very carefully and put in a new ball. In regrinding the suction valve only the slightest pressure should be put on the stem. In using this pump you may find the discharge valve leaking even when the seat is perfect. This is due to the lag of the valve. If the valve guard allows it to lift more than $\frac{1}{16}$ in., the valve cannot return quick enough to cut off the oil flow. When using distillate oil, a spring placed over the ball will increase the closing speed and decrease the leaking.

"Another point that often puzzles the operator is the leaking that shows up on a change of oil, especially from a heavy to a light oil. It does not require a very good valve to seal when a heavy oil is used; but as soon as distillate is substituted it is impossible to operate without regrinding the valves.

"The links that move the suction valve are adjustable. To equalize the fuel charges delivered by the several pumps to their respective cylinders, block up the governor to its highest point and turn the pumps by hand, and see that the suction-valve stems are depressed equal amounts. Then, with the governor in its lowest position see that the clearances between the stems and the rollers are the same—this should be 1/100 in. To prevent the governor from hunting, the suction valve should open when the pump plunger is at the middle of its suction stroke, and the suction valve should close when the plunger is at its midposition on the delivery stroke. This is when the governor is blocked to its full-load position.

"A sectional view of the pump used on the Busch-Sulzer engine is shown in Fig. 2. The fuel plunger *A* is driven by an eccentric *B* on the vertical shaft *C*, which is driven by the crankshaft and gives motion to the camshaft. The plunger *D* is driven by the eccentric *E* on the shaft *C* and opens the suction valve through the bell-crank *F* carried by the eccentric *G* on the shaft *H*. The shaft *H* is connected by levers *I* and *J* to a collar *K* that is under control of the governor.

"The plunger *A* is timed to discharge oil into the needle-valve cage when the engine piston is on the suction stroke. The plunger *D* is arranged to open the suction valve when the plunger *A* is at about midposition on its suction stroke and to close the suction valve when the plunger *A* is at about midposition on its discharge stroke, with the engine under full load.

"If the engine speeds up, the governor moves the collar *K* upward, and, as shown by the dotted positions of the levers *I* and *J*, turns the shaft *H* and swings the eccentric *G* to a higher position. As a result, the bell-crank lever *F* strikes the suction-valve stem sooner and gives earlier opening of this valve. When the engine is to be stopped, the cam *L* is turned until it forces the

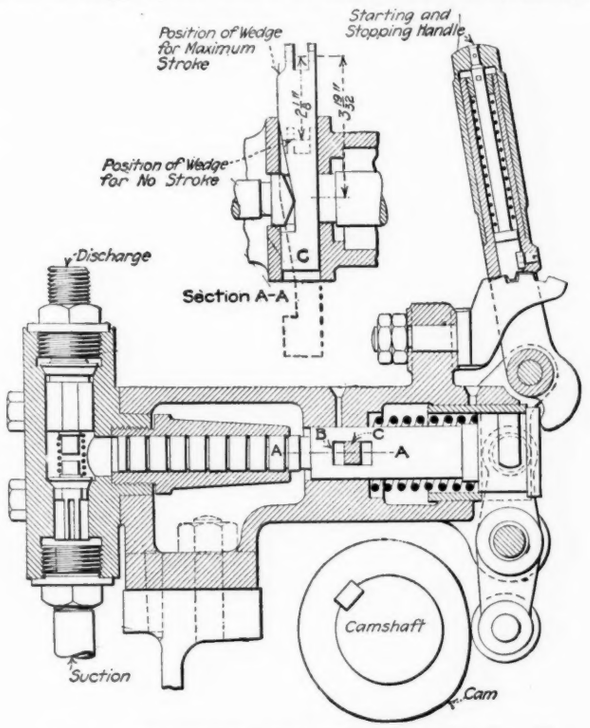


FIG. 5. FUEL PUMP OF McEWEN DIESEL ENGINE

suction valve off its seat and holds it there during the whole discharge stroke. To fill the fuel line, preparatory to starting, a further movement of the cam causes the dog to raise both the suction and the discharge valve.

"This pump probably regulates closer than any other type. The governor has no great frictional resistance to overcome, and so its smallest movement is communicated to the pump.

"In this pump there are but three things that cause trouble. The first is the plunger packing. It's important that the plungers be carefully packed to prevent leaking; nevertheless don't put too much pressure on the packing or the plunger will score. The second is the suction valve. This valve will leak if gritty oil is used, and if the oil carries much sulphur, pitting on the valve faces will occur. The third source of trouble is the discharge valve. Its springs often break and the valve itself will not seat quick enough to keep the oil from flowing back. In making up valve springs I've found it is best to anneal the spring wire before winding it to size and then harden it. In this way you don't get the surface fractures that will occur when the spring is wound without annealing."

"Chief, how often ought the pump valves to be ground?" Woods inquired, seeing that Egan was about ready to take up another pump.

"That depends on the kind of fuel oil. With ordinary Diesel engine oil that has been filtered, I should say once every three months. With a heavy grade of oil, such as we receive at times, you'll find them cut bad enough to warrant regrinding in thirty days.

"There's one other little kink," Egan continued, "that you mustn't forget. Each time the suction valve is ground, the valve is lowered and this lowering will cause the bell-crank lever to strike the stem earlier in the stroke and hold the valve open longer. The consequence is that this particular engine cylinder will not carry its proper share of the load.

"The McIntosh & Seymour engine uses a variable-stroke type of fuel pump, and Fig. 3 shows a section of it. There are two outside-packed plungers *A* that move in unison and that are given a reciprocating motion by the eccentric *B* keyed to the shaft *C*. A second eccentric *D* fits over the eccentric *B* and is connected by links to the governor on the upper end of the shaft *C*. Thus, with a variation in speed, the governor rotates the outer eccentric *D* somewhat and so alters the stroke of the pump plungers, since they are driven by a strap *E* on the eccentric *D* and an eccentric rod *F*. The oil is discharged through the pipes *G* to the engine cylinders. As the pump stroke is changed, the amount of the fuel charge is correspondingly altered. This pump needs little attention beyond an occasional repacking of the stuffing-boxes and regrinding of the valves."

"Mr. Egan," Woods interjected, "you say that the pump doesn't govern the fuel charge by opening the suction valves *H*. If that's the case, what's the use of the cam and those two levers above the suction valves?"

"They're used when the engine is stopped," explained the chief. "The cam is turned, forcing the suction valves open, and so no oil is pumped. A further movement of the cam raises the suction valves higher still and holds the discharge valves open. This is the position when the fuel lines are filled prior to starting.

"The pump used by the Allis-Chalmers Co. also regulates the amount of fuel delivered to the engine by changing the length of stroke of the plunger. Fig. 4 shows a cross-section of the pump. The plunger *A* is given a reciprocating motion by the action of the eccentric *B* through the drive rod *C* and the lever *D*. The lever *D* is fulcrumed on a pin *E* carried by the short arm of a bell-crank lever *F*, the long arm of which is connected to the governor mechanism by the rod *G*. If the speed of the engine decreases, the rod *G* is drawn upward, causing the pin *E* to be lowered. The rod *C* then receives an increased lift from the cam and the pump plunger makes a longer stroke, delivering more oil."

Woods broke into Egan's discourse.

"It looks to me as if there would be a big load on the governor when the plunger began to pump the oil."

"So there would, my boy, if the pump was handling the oil against a high pressure; but in the Allis-Chalmers engine an open nozzle is used. Oil is delivered during the suction stroke of the engine, and so there is only the friction of the oil in the fuel line to be overcome.

"To keep this pump in condition a little regrinding and attention to the fulcrum pins is required. Among engineers there is a tendency to allow pins to wear badly before renewing. You can see that a small amount of wear would affect the governing. Don't be afraid to true up worn pins or to ream the bearings and insert new brass bushings.

"The next illustration, Fig. 5, is a cross-section of the pump used on the McEwen engine. This pump regulates by the governor altering the length of the suction stroke of the pump plunger. As shown in the section *AA*, the plunger has a slot *B* in which is a wedge *C* under control of the governor. A movement of the sleeve causes the wedge to move, increasing or decreasing the length of the suction stroke of the pump, and so altering the fuel charge. No packing is used, dependence being placed on the oil sealing the plunger. Since the nozzle used is an open one, the discharge pressure is negligible. The oil seal usually is found satisfactory. If you ever run an engine having this type of pump and have to renew the plunger spring, make it of larger size wire. It will make the plunger snappier in action. The Snow engine employs a pump with a wedge adjustment quite like this one.

"Outside of the little details that require attention on all pumps, you can say that the fuel pump is about the least troublesome of all the Diesel-engine parts. Of course, when you use heavy, tarry or dirty oil, the valve of any make of pump will cause trouble, but that happens only when a good filter is not used. However, we'll talk of filters another time."

Unnecessary engine friction can be overcome by thoroughly lubricating the valve seats and walls of the cylinder, but no hard and fast rule can be given regarding the amount of oil to be fed to steam engines. It is necessary to take into consideration the kind of valves, whether rotative or slide valves, balanced or not; the speed of the engine, whether high or low; whether low-pressure and moist steam, or high-pressure and comparatively dry steam is being used.

As soon as steam leaves a boiler, the tendency is to condense or to return to water, due to the radiation of heat. A bare pipe containing steam, when exposed to still air will condense less steam than when the pipe is exposed to air in motion.

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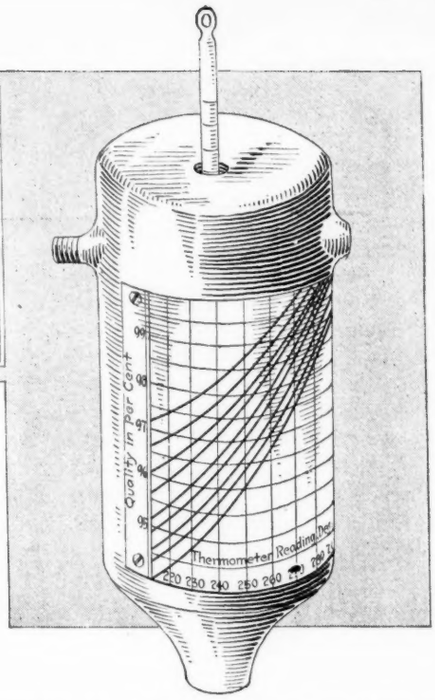
An Improved Form of THROTTLING CALORIMETER

By

*W. R. Woolrich**



When using the throttling calorimeter, the data of the test are substituted in a formula or are used in connection with a curve sheet to find the quality of the steam. This article explains how the instrument may be made self-contained by having the necessary curves drawn on a metal plate fastened to the barrel of the calorimeter. Thus, having observed the initial pressure of the steam and the temperature in the calorimeter, the quality can at once be found from the curves on the plate.

ENGINEERS know very well that the steam furnished by the average boiler is not dry saturated steam, but that it contains more or less moisture. Then, 100 minus the percentage of this moisture, by weight, is called the quality of the steam, and a common way of finding the quality is by the use of the instrument called the throttling calorimeter, one form of which is shown in section in Fig. 1.

The steam to be tested flows from the steam main through the sampling pipe *A* and the valve *B* and then passes through the small throttling orifice *C*, escaping into the interior of the barrel *D* of the calorimeter. From this chamber it flows out into the open air by way of the exhaust opening *E* at the bottom. The U-gage *F* is connected to the interior of the calorimeter by the pipe *G* and is used to measure the slight pressure existing inside. A thermometer *H* is inserted in a well extending down into, and is used to find the temperature of the steam in the calorimeter.

In making an accurate test for the quality of steam, the pressure of the steam in the main is observed, the temperature of the steam in the calorimeter is read from the thermometer, and the pressure inside the calorimeter, above the pressure of the atmosphere, is read from the U-gage in inches of mercury. Then, by the use of a somewhat lengthy formula,[1] the quality of the steam may be calculated.

The use of the U-gage, while desirable in extremely accurate performance tests, is not necessary for ordinary work. All that it does is to make correction for the slight pressure existing inside the calorimeter, above atmospheric pressure, and this correction does not affect the quality of the steam by more than a few hundredths of one per cent. The operating engineer is justified in omitting this correction, therefore, and by so doing he simplifies the matter of finding the quality of the steam.

Neglecting the U-gage reading simply means that the pressure inside the calorimeter is assumed to be equal to that of the atmosphere, or 14.7 per sq.in. Under these conditions, the quality of the steam may be found by the formula[2]

$$X = \frac{1050.8 + 0.476\,T - h}{l}$$

in which the various letters have the meanings given in the first footnote. Thus, for any given test, T becomes the temperature indicated by the thermometer in the calorimeter and h and l the heat of the liquid and the latent heat at the absolute pressure in the steam main, as found from the steam tables.

The trouble with this method, however, is that it requires the finding of certain values from the steam tables and then a number of calculations as indicated by the formula. As a result, technically trained men are practically the only ones that use it. Few operating engineers have mastered the use of the throttling calorimeter for finding the quality of steam. This statement is no reflection on stationary engineers, but rather emphasizes the failure of the makers of calorimeters to put on the market an instrument that required no knowledge of thermodynamics in its operation.

Some calorimeter manufacturers have tried to get around this objection by sending out with their instruments curve sheets from which the quality of the steam can be read off when the steam pressure and the reading of the calorimeter thermometer are known. This is a

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*Assistant professor of mechanical engineering, University of Tennessee.

[1]The formula ordinarily used for finding the quality of steam is:

$$X = \frac{L + H + 0.476\,(T - t) - h}{l}$$

in which

X = Quality of steam;
L = Latent heat of steam at absolute pressure in calorimeter;
H = Heat of liquid at absolute pressure in calorimeter;
T = Temperature indicated by thermometer in calorimeter, in deg. F.;
t = Temperature of dry saturated steam at absolute pressure in calorimeter;
h = Heat of liquid at absolute pressure in steam main;
l = Latent heat of steam at absolute pressure in steam main.

[2]Since the pressure in the calorimeter is taken as 14.7 lb., the values of L, H and t in the formula given in the first footnote are 971.7, 180 and 212, and the formula then becomes $X = \frac{971.7 + 180 + 0.476\,(T - 212) - h}{l}$ which reduces to $X = \frac{1151.7 + 0.476\,T - 100.9 - h}{l}$, or, finally, $X = \frac{1050.8 + 0.476\,T - h}{l}$

step in the right direction, but it requires the curve sheet to be kept at hand to interpret the results from the calorimeter. Now, the operating engineer is only human, and he will always look with disfavor on any device that requires the use of a book or a curve sheet to enable him to interpret the information he has obtained. He will demand an instrument that he can demonstrate to friend or boss without having to apologize for not having the necessary tables or curves with him.

Numerous attempts have been made at the University of Tennessee to train practical operating engineers to use the throttling calorimeter in connection with both tables and curve sheets; but the instrument lacked completeness in that it would not give results by looking at it or studying it alone. It required too much auxiliary information and computation. This obstacle has been overcome by preparing a set of curves to interpret the readings of the calorimeter and mounting these curves directly on the outside of the barrel of the instrument. The simplest way is to make a flat metal plate with the curves and values marked thereon, bend it to fit the cylindrical barrel of the instrument and fasten it with screws.

Fig. 2 shows such a plate with the curves drawn thereon for pressures between 40 and 250 lb. gage. These curves have been plotted from the values given in Goodenough's steam tables, and the method of using them is very simple. To illustrate, suppose that the steam pressure in a certain test is 80 lb. gage and

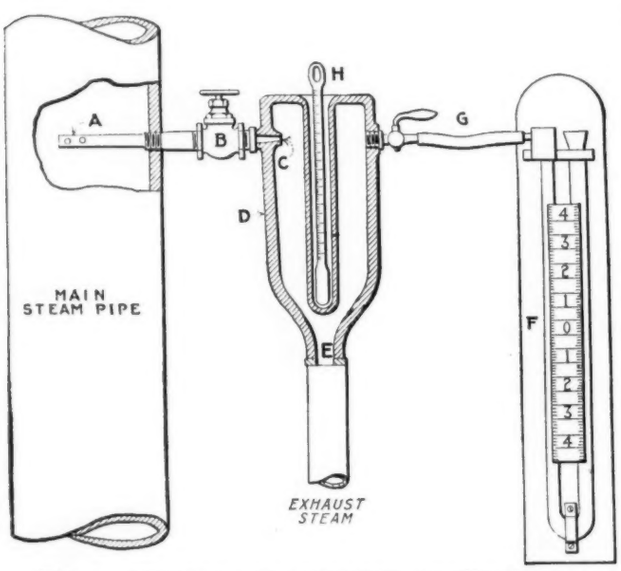


FIG. 1. GENERAL ARRANGEMENT OF THROTTLING CALORIMETER

that the calorimeter thermometer shows a temperature of 250 deg. F. To find the quality of the steam under such conditions, the engineer puts the point of his pencil at 250 on the horizontal scale, moves it vertically upward till it strikes the diagonal marked 80 and then moves horizontally to the scale at the left, where the value 98 is found. Then the quality of the steam is 98 per cent.; or, the steam contains 2 per cent. of moisture.

If the observed pressure and temperature lie between the values marked on the plate, the position of the points can be judged closely enough to give the quality of the steam to within one-tenth of one per cent. of the true value. The lines on the plate may be engraved, etched or die-stamped.

This improvement makes the calorimeter self-contained and by its use it has been possible to train men in a very short time to make tests for quality of steam. It is no longer an instrument that needs outside

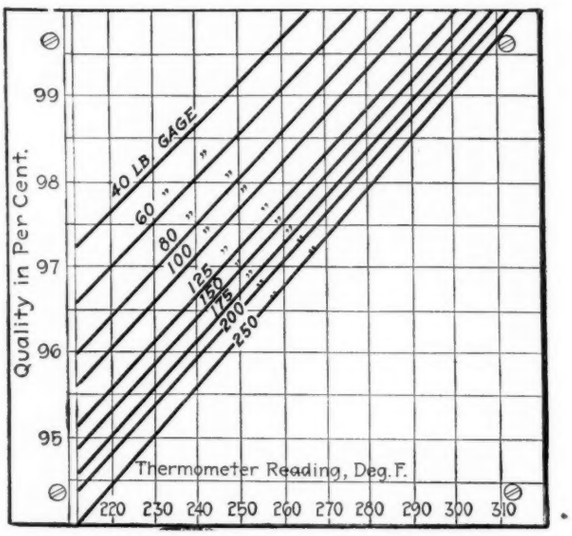


FIG. 2. CHART FOR FINDING QUALITY OF STEAM

assistance. The engineer takes a kindly interest in it, for it tells him at once what he wants to know without his consulting anybody or anything else.

The barrel of the average throttling calorimeter is about 3 in. in diameter and 6 in. long. Therefore, if the plate containing the curves is made 5 or 6 in. square, it will doubtless fit the outside of the barrel when it has been bent to the proper curvature.

Central-station service or isolated plant, and if central station shall it be municipally or privately owned, was the subject of a discussion between L. W. E. Kimball, representing the Brotherhood of Electrical Workers, and W. Rodman Peabody, counsel for the Turners Falls (Massachusetts) Power and Electric Company. The occasion was a hearing on a bill before the Massachusetts legislature providing for the establishment of a state commission to investigate the power resources of Massachusetts and to establish data bearing upon the public-ownership policy. Mr. Peabody, was legal adviser of the Massachusetts Fuel Administration during the war and has been identified with the Turners Falls hydro-electric and steam developments since their inauguration under the direction of Philip Cabot, of Boston. It is hardly necessary to say who took the pro and who the con of the argument, and our advices fail to show that any determinative thought or suggestion was evolved. It is interesting to know that the subject is still a matter of public discussion in the Old Bay State.

The friction of superheated steam is much less than that for saturated steam in passing through the engine steam ports and passages, and the sectional area of the steam pipe can be made smaller than that required for saturated steam.

EDITORIALS

Marking Time in the Coal Industry

STUDENTS of political economy sagely advise us that the prices of commodities are dependent on the relation of supply to demand, leaving out of consideration, of course, such artificial conditions as may be created by Governmental price-fixing or other methods of interference. Inasmuch as the control exercised by the Fuel Administration over the coal industry of the nation has been discontinued and all restrictions removed, it would seem as though the law of supply and demand ought to be functioning in splendid form; but it is not, and no one seems to understand just why.

The latest bulletin of the Fuel Administration announces that coal is more plentiful now than it is likely to be for a good while to come and advises retail purchasers to place orders at once for their next winter's requirements. Taking this announcement at its face value, the combination of a plentiful supply and a low demand ought to produce low prices. Instead, the very opposite has occurred. Not only have prices failed to fall, but the anthracite operators have declared an increase of ten cents a ton, effective April first, and there is no April-fool joke intended, either.

In all the tumult of conflicting testimony one fact stands out clearly. To go through a normal winter without discomfort, this country requires a definitely known amount of coal, so that the mining industry is fully aware of the minimum yearly demand. Fuel is a necessity, not a luxury. It cannot be dispensed with for any length of time without causing suffering. Therefore, the operators know that an amount of coal equal to the consumption in a normal year is bound to be absorbed by the domestic and manufacturing interests every twelve months.

What is to prevent the operator from anticipating this certain market by storing coal against the time of increased demand? Coal—particularly anthracite—does not deteriorate in storage, so there can be no objection to the practice from that angle. True, there is some breakage due to rehandling, causing degradation of size, and the expense of rehandling will add to the cost of the coal. But the practice of storing would keep the mines working continuously throughout the year, do away with part-time labor and insure a sufficient supply to meet the demand when cold weather arrived to stimulate the market.

Coal operators seem to be unanimously of the opinion that the wages of the miners will not be reduced. Many predict increases—or, what amounts to the same thing, a shorter working day without a corresponding reduction of wages. If this is assumed, it is apparent that the cost of production will not be decreased by waiting for more auspicious labor conditions.

To the man in the street the whole situation takes on the appearance of a freeze-out. The operator continues to run his mines on short time, content with producing just enough to fill the relatively small orders that come in. The mine worker submits to this state of affairs with as good grace as may be expected, but looks forward to improved conditions in the near future, his outlook having been considerably brightened by the adoption of the demands of British miners for a five-day thirty-hour week. The consumer, numbered by the millions, looks on with anger and dismay, undecided whether to put in his order now or not. And so the three sit tight, waiting, watching, hoping.

The distressing part of the situation is that the consumer has no chance to win. Whatever may be the outcome, he will be the victim. If the wages of miners remain unchanged, he will still pay increasing prices for coal, according to the schedule announced; if the wages of miners are raised, he will pay the increase, and then some; if he puts in his orders now, and coal prices should unexpectedly drop, he will be the loser; and if he holds off until cold weather compels him to order, he will be mulcted by the high prices that always prevail when coal must be had and the available supply is almost invisible. Confronted by such a hopeless situation, there can be little fault found with him if he does what the others are doing—marks time.

The 70,000 Kilowatt Turbine at Muscle Shoals

FEW steam turbines of greater than five hundred kilowatts had been built up to 1900. In this issue is described one of seventy thousand kilowatts, maximum. Such has been the sweeping progress in the interval.

The machine described is the one installed in United States Nitrate Plant Number Two, at Muscle Shoals, Alabama. It is of the compound, triple-cylinder, pure-reaction, parallel-flow type, consisting of a high-pressure turbine running at eighteen hundred revolutions per minute and two low-pressure, semi-double flow machines operating at twelve hundred revolutions per minute. Each turbine drives a generator.

The demand for greater capacity in one unit has led to the use of three cylinders, as exemplified in the seventy thousand-kilowatt, maximum, turbines, one in the Seventy-fourth Street Station, New York City, the other in the nitrate plant at Muscle Shoals, Alabama. In *Power* of September 15, 1914, Francis Hodgkinson, designer of the multicylinder reaction turbines in use in the United States, stated the advantages of such design to be as follows, saying that the reasons were more forcible the larger the capacity of the machine: Smaller cylinder structure; smaller temperature range within a cylinder; no limitations to the design preventing the attainment of the highest efficiency; possibility of separating moisture midway of the steam expansion.

The design permits also of low blade speeds, comparatively. In the machine described in this issue the mean blade speed in the last row of each low-pressure element is 514 feet per second. The water rate is best at fifty thousand kilowatts, at which load it is 10.55 pounds per kilowatt-hour at 290 pounds pressure absolute at the throttle, 175 degrees Fahrenheit superheat and 29 inches of vacuum.

The flexibility of this unit is of interest, particularly because it is the only main unit in the station now that plans for using a thirty-thousand-kilowatt machine have, for the time being, been abandoned. There are high-pressure steam connections to the low-pressure elements, and should one or the other fail, or should the high- and one low-pressure element fail, the elements or element not incapacitated would continue to run. The reader will be interested in the automatic and manual control of the unit as told in the article.

Power-Factor Correction

IN SELECTING induction motors for a given drive it is of vital importance that the motors be chosen so that they will operate as near full load as consistent with standard-size machines. If a direct-current motor is only partly loaded, it results in a slightly lower efficiency and a higher cost of installation, which in many cases is offset by lower maintenance charges. However, when induction motors that are too large for the load they are to drive are installed, the cost of installation is not only higher and the efficiency of the motor lower, but the power factor is very materially decreased without any reduction in maintenance charges.

It is a well-known engineering fact that induction motors never, even when fully loaded, can operate at unity power factor. The best power factor that can be expected is approximately eighty-five per cent. lagging. However, when lightly loaded, the power factor is very low, resulting in low efficiency of the motor, distribution and transmission systems and generating equipment.

As the power factor decreases in a system, the current must increase in almost direct proportion to transmit the same power. With fifty per cent. power factor, to deliver the same power at the end of the line requires more than double the current flowing in the system as for unity power factor, which will increase the line and generator losses more than four times and reduce the available generator capacity at least fifty per cent., not considering the bad effects upon voltage regulation.

During the last three or four years the size of motors installed to do a given work has in many cases been dictated by the size that could be obtained and not what good engineering practice prescribed. If a five-horsepower was the proper size and earlier deliveries could be obtained on a ten-horsepower, the latter was not infrequently installed. Large manufacturing plants sprang into existence over night, the motors had to be obtained from somewhere, and practically the only consideration given was that they would operate on the power voltage available and large enough to carry the load. Consequently there are in operation many industries in which the motors are carrying only a small percentage of their rated load. This has resulted in a lowering of the power factor of a great many of the power systems all over the country, with its attending bad effects.

For some time past some of the larger central stations have offered inducements to their customers for maintaining their power factor above a certain prescribed value. However, owing to the conditions that have been brought about by the perfunctory installation of induction motors during the war period, this movement on the part of the power companies has become practically nation wide. Of course much can be done toward correcting the power-factor system by installation of synchronous apparatus in the various substations on the system of the power companies, but the place to correct the power factor to obtain the greatest advantage is where low power factor occurs, which in most cases is in the plants that have lightly loaded induction motors. In almost every large industrial plant there are some large drives that require constant-speed motors and not excessive starting torque, which can be just as successfully driven by large synchronous motors as by induction motors. It is such drives that can be taken advantage of for power-factor correction, the synchronous motor being selected large enough not only to supply the power component of the load, but also to supply a leading wattless component to neutralize at least part of the lagging wattless components due to the induction motor load.

There has been a tendency in the past by many of the industries that purchase power to consider the power factor of the system something for the power company to worry about. But one has only to consider the result of low power factor to see that such an attitude is erroneous. First, if induction motors are installed too large for the work they are to do, the cost of installation is higher than it should be. If the voltage regulation is poor the speed regulation of the motor is also poor, resulting in a decrease in production and in some cases an inferior product. The excessive losses in the distribution system and in the transformers, the latter where primary power is purchased, must be supplied from the generator in the power house and therefore passes through the meters at the manufacturing plant and appears as power used by the purchaser at the end of the month, consequently this is not quite so much a one-sided question as at first might appear. This is especially the case in isolated plants, for the total losses due to lower power factor are chargeable to the cost of manufacturing, whether it is or not when power is purchased. However, somebody has to pay the bills.

Reliable Refrigeration Data

IN ANOTHER column of this issue is an appeal on the part of a contributor for coöperation among engineers, especially on subjects pertaining to refrigeration. Information is desired particularly on ammonia condensers and on the new designs of ammonia compressors, especially the high-speed type.

Power has always taken a stand in favor of mutual service. Its aim has been to be the means of spreading information on steam and other allied engineering subjects. In its study courses, its specially prepared articles and its correspondence columns it attempts to make it possible to keep the operating and designing engineer thoroughly up to date.

In the matter of refrigerating data it seems especially necessary to ask our readers to send in their information. For some reason or other it appears that engineers are not progressing as satisfactorily in the refrigerating field as in other branches of engineering, so far as gaining reliable facts is concerned. The refrigerating companies are too busy or are not properly equipped to obtain test data. Enthusiastic claims are sometimes made on special designs or new machines, which are not substantiated in practice. It is clear, then, that reliable data can be obtained best from the field—by the owners or the operating engineers.

Correspondence

Water-Column Blowoff Valve

Having numerous high-pressure boilers in my charge, I have had considerable experience with water-column blowoff valves. The letter by R. A. Williams on page 140 of the Jan. 28 issue of *Power* brought to mind many of the troubles I have had from these valves leaking. Mr. Williams says that he extended the pipe from the bottom of the gage-glass and put the blowoff valve on the lower end of the pipe. On all large boilers these valves are located as he states, but the valves on our boilers continued to leak.

After looking into this matter to find out why these valves should give so much trouble, I discovered that all the globe valves were so placed that the pressure, when closed, came under the disk, Fig. 1, so that the valve stem might be packed while the boiler was under pressure.

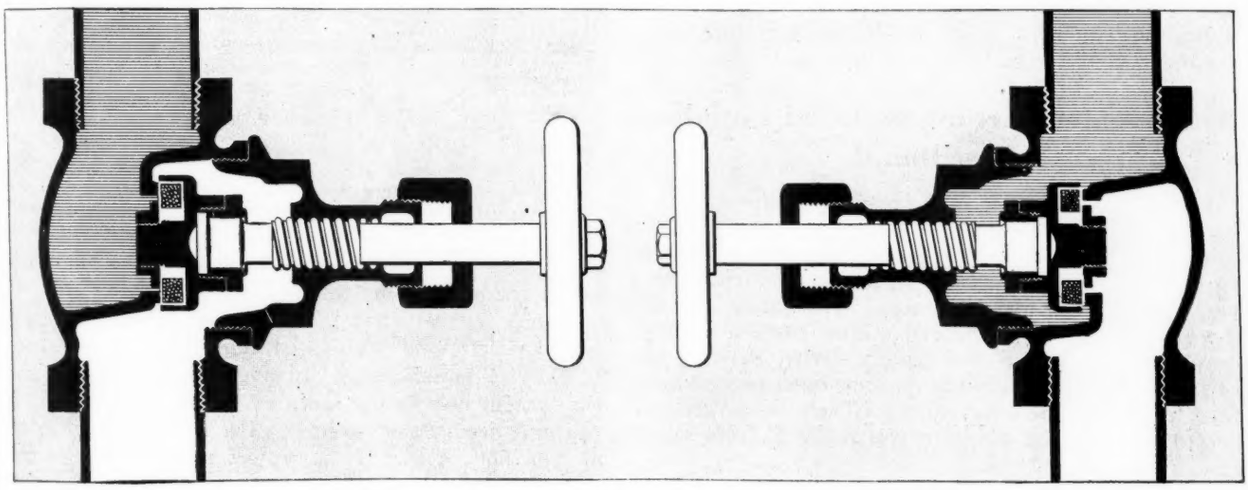


FIG. 1. PRESSURE UNDER THE VALVE DISK

FIG. 2. PRESSURE ABOVE THE VALVE DISK

It was then decided to pipe all water-column blowoff valves so that when closed the pressure would be on the top of the seat. The reason for doing this was that when blowing down the water column with a valve set so that the pressure came under the disk, the stem would be heated to the temperature of the steam in the boiler, and the expansion of the stem would be governed by its temperature. Then after the valve had been closed long enough for condensation to take place, the stem would contract and allow the valve disk to leave its seat. This would cause the valve to leak unless the attendant turned the valve wheel to take up the contraction that had taken place.

But when placed so that the pressure comes on the top of the disk when closed, Fig. 2, the disk will be held in place without being forced to the seat by the valve stem. With this method of piping, our valves have given many times the service they did before the change was made.

THOMAS J. PASCOE.

Norway, Mich.

Overheating Hot Water Wasteful

I have been interested in the articles that have appeared in *Power* regarding the overheating of hot water, and while the contentions brought out by various engineers are correct as far as they go, it seems to me that there is one point that they have overlooked, and this applies especially to office buildings and factories where a large quantity of water is used by the people in the washrooms.

The common practice in many instances is to have a combination hot- and cold-water valve, and by turning the valve handle a certain extent various degrees of temperature of the water coming from it may be obtained. If the hot water is at a high temperature, the user will generally be obliged to turn the valve wide open in order to get enough cold water to temper the flow so that it can be used without scalding. Under such circumstances much water goes to waste, in fact three or four times as much as would be used in case a lower temperature of hot water were carried.

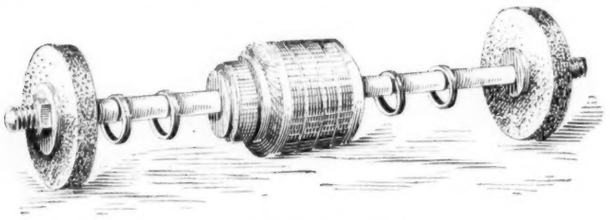
This same thing can happen in the case of wash basins, where the custom is to open both the hot- and cold-water faucets, and if the water is at a high temperature the water in the bowl is too hot to use, and consequently more cold water is run into it to bring the temperature down; so much so that a large quantity generally will escape through the overflow. Of course this is a waste of water, both hot and cold, and such waste will bring the cost of the raw water up considerably in the course of the year.

Not only is cold water wasted in quantity, but the heat used in bringing the hot water up to a high temperature is lost in part, as more hot water is used than is necessary, and it goes to the waste pipe.

Paterson, N. J. L. A. HIGGINS.

Why Do Oil Rings Wear Grooves in Shaft?

I have had considerable trouble with a motor-driven grinding machine used for grinding steel castings. This trouble is confined to the bearings, which are of the ring-lubricated type, and the rings wear a groove in the steel shaft, although the bearings are supplied



COPPER RINGS WORE SHAFT

with plenty of oil. They are in line and run cool. So far the only remedy has been to put in a new shaft, but in a short time the grooves are worn the same as before.

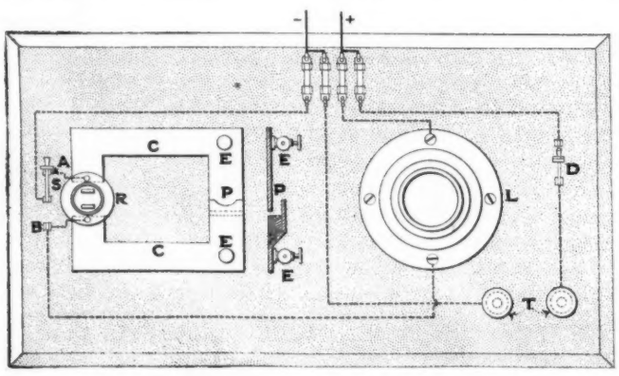
The shaft runs at 960 r.p.m. and is 3 in. diameter. The oil rings are of copper. Can anyone who has had a similar experience suggest a remedy for the difficulty?

WILLIAM H. ROBERTS.

Lima, Ohio

A Convenient Arrangement of Plug-Fuse Test Board

I have been interested in the articles on electrical testing outfits appearing in *Power* and have constructed a test board of an arrangement somewhat different from any other I have seen, which has proved to be a very useful device about the shop. The figure indicates the construction of the board. Plug fuses are tested by placing them at *P* and closing switch *S* to *A*, and cartridge fuses are tested by placing them so that their ferrules rest on the brass strip *C*. These strips are connected to the terminals of a receptacle *R* from which



ARRANGEMENT OF DEVICES ON TEST

an extension cord may be taken for testing equipment on the bench or shop floor. The receptacle may be replaced by binding posts *E*, as shown. Terminals *T* are for supplying power, by closing switch *D*, to any small equipment that comes within the capacity of the fuses mounted on the board. By closing the switch *S* to *B* the lamp *L* will burn continuously and may be used for lighting around the bench.

W. W. PARKER.

Electrical Division, U. S. S. "Texas."

New Design of Crank-Rod Wedge Adjusting Bolt*

The frequent references to breaking wedge bolts in the correspondence column of *Power* are of special interest to me, as I have had numerous experiences with this troublesome occurrence and have been called upon to replace these bolts when the connecting-rod had to be removed to let the new bolts in. I have also seen wrecks caused by pieces of broken bolts becoming wedged in some part of the engine.

Some causes of breakage may be eliminated, such as holes out of line, poorly fitting wedges, etc., but I have had engines that would break the bolts in time no matter how carefully they were fitted. I had charge of a large gas engine that gave considerable trouble in this way, and after many shutdowns and various experiments I developed a design of wedge bolt and lock which seem to be immune from destructive forces. I have tried this bolt out thoroughly on gas and steam engines and can guarantee it to stand the strain put upon it.

Fig. 1 shows the original bolt, which is provided with a hole for a key wrench, also a cross-section showing the lock setscrews with copper shoes on the threaded ends. Fig. 2 is a modified form using a common headed

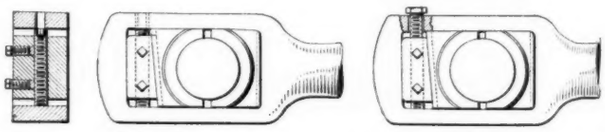


FIG. 1. ORIGINAL BOLT

FIG. 2. MODIFIED FORM OF FIG. 1

bolt. This works well in practice except that the wedge cannot be loosened by turning the bolt.

It may appear that the wedge would jump, but in actual practice on high-speed engines I have found it is entirely satisfactory. In applying this bolt I plug the bottom hole in the strap of the ordinary design of rod and dress it off evenly. The outstanding feature of this bolt is that it is subject to compression only and it is free to float with the wedge, and the long thread through the wedge makes a powerful jackscrew that is easily locked and will not break.

I have adopted the bolt shown in Fig. 1 and consider it to be more practical, though a little harder to make and apply. The bolt must strip the long thread or be crushed before the wedge can get loose, and I have not yet seen the engine that will do it. After using this bolt for about two years with heavy-duty and high-speed gas and steam engines that were in the habit of breaking bolts made from special materials, I have satisfied myself that my arrangement will stand the test.

A wedge bolt is an insignificant part of an engine, and as long as it holds it is seldom thought of; but when it breaks and the brasses get the full play of the strap an engineer is out of luck. I know from experience that it is a mighty consoling feeling to know that the bolt will not break and especially so when there are hundreds of workmen depending on the engine for power, to say nothing of the loss of production.

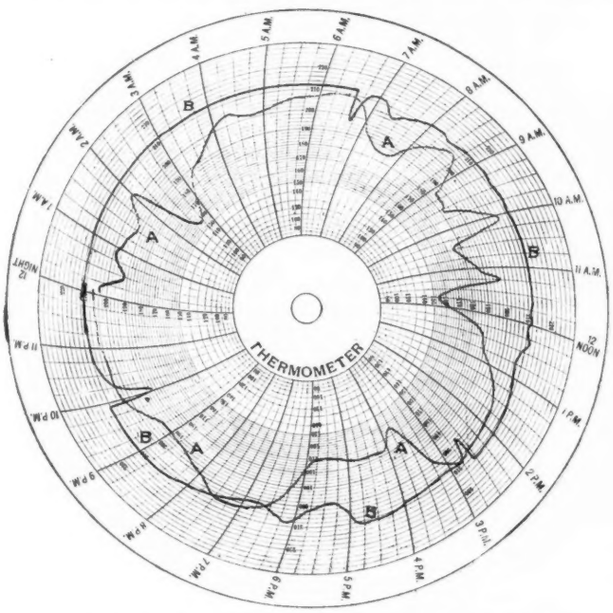
Oil City, Penn. LLOYD R. HOFFMAN.

*Patent applied for.

Using Charts Over Again

The accompanying chart is for the same date of last year and this year where the operating conditions were practically the same, and shows two chart records.

A red line *A* is for Feb. 3, 1919, with an average feed-water temperature of 193 deg. F., and a green line *B* is for Feb. 3, 1919, with an approximate average temperature of 209 deg. F. The operating conditions



TWO TEMPERATURE RECORDS ON ONE CHART

on both days were practically the same, but on Feb. 3, 1919, 3600 lb. less coal was burned than on the same date last year. The outside temperature on Feb. 3 last year was 22 deg. F.; the average outside temperature on Feb. 3 this year was 31 deg. F., taking it for the entire 24 hours.

I mention the temperature because it has an important bearing on the operation of the plant. This comparison shows very plainly to me what a fireman can do if he feels like it. Of course the higher temperature this year would account for some saving in coal, were it not for the fact that the coal burned was very much poorer than what we had last year, and would, I am sure, offset any saving due to higher outside temperature.

W. R. GROOM.

New York City.

What Makes the Exciter's Voltage Slow To Build Up?

In our plant we have two steam-engine driven 110-kv.-a. 2300-volt alternators, with a 7.5-kw. direct-connected compound-wound exciter on each. The machines are not operated in parallel since the power requirements are such as to make this unnecessary. The voltage of each machine is controlled from the same regulator.

One of the machines will respond quickly to load changes and the other is sluggish. The exciter on the sluggish machine is slow to build up its voltage, consequently the alternator is slow in coming up to full potential. It sometimes requires 10 to 15 minutes for the exciter to come up to its full rated volts when first started. If the series- and shunt-field windings are in opposition, would this cause the trouble? I would like to hear the opinion of *Power* readers as to the cause of the difficulty. I might add that the alternators are supplying power to mine motors and at times there is a swing from practically no load to full load. What is the answer?

C. S. HARRISON.

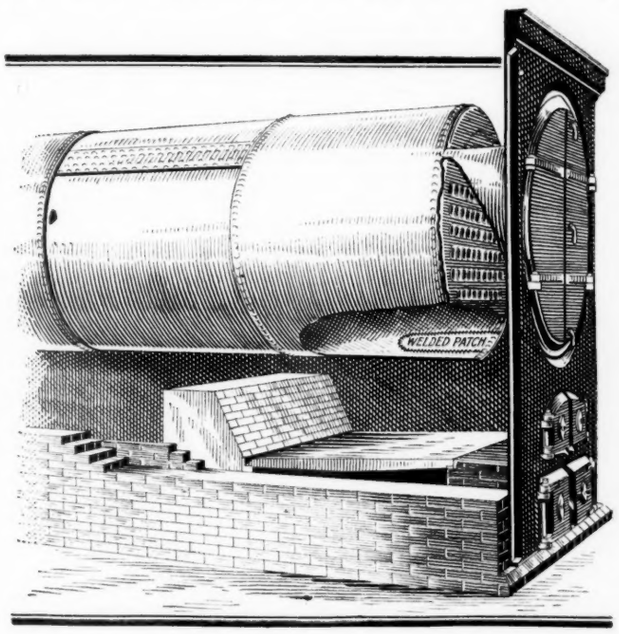
Courtland, Ariz.

Boiler Patch Welded In

To those interested in welding of boiler plates by the oxyacetylene method, a weld made on a boiler in the Western Commercial plant at Wayne, Alberta, may be of interest.

This is a plain return-tubular boiler and was supplied with water by an injector from a stream carrying considerable mud. Mud collected over the fire sheet, and a bulge formed about the size of a man's head. This bag was close to the head so that the plate was cut out from the head back far enough to take out all damaged material, and a patch was riveted on in the ordinary manner.

Much trouble was experienced with this patch leaking, and the inspector finally gave his consent to try a weld. The shell was again cut out from the head back, taking out all rivet holes, and a patch was cut to fit the opening and placed inside the boiler plate and welded so that the two plates are on the same plane and not lapped. The boiler was tested up to 200 lb. gage with hydraulic pressure and is now working



PATCH WELDED TO FIRST SHEET OF RETURN-TUBULAR BOILER

under a steam pressure of 125 lb. So far it has proved a good piece of work and no further trouble has been experienced.

H. E. WIGHT.

Drumheller, Alta., Canada.

(The Code of the American Society of Mechanical Engineers does not allow the use of a weld under pressure unless the stress is taken up independently of the weld.—Editor.)

Throttle Had Too Much Play

I was recently called to a plant that has a 1500-hp. cross-compound Corliss engine driving textile machinery. The engine suddenly showed difficulty in taking care of the regular load of about 1000 hp. Indicator diagram *A*, Fig. 1, had been taken a few days previously, but card *B* was the best that could be obtained

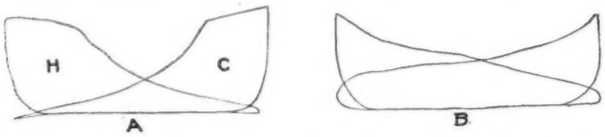


FIG. 1. TWO SETS OF DIAGRAMS FROM SAME ENGINE

when I arrived. The dropping steam line showed wiredrawing, a throttling effect on the steam, or the piston leaking badly.

Notes of the water used in the condenser showed no increase over previous days, and equally good vacuum eliminated the possibility of a faulty piston. A steam gage at the receiver separator near the throttle showed practically full boiler pressure, so the trouble evidently was at or near the throttle valve. This valve was one that opened away from the operating wheel, having a left-hand thread on the stem, Fig. 2. The stem also actuated the bypass.

The cover was removed from the valve after work hours, and it was found that the nut holding the valve disk in place had moved back to such an extent that the main disk remained on the seat when the stem had reached its limit, allowing only the steam that passed

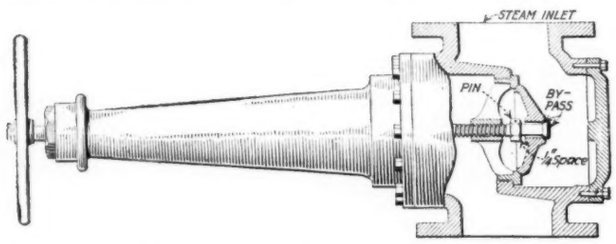


FIG. 2. TYPE OF VALVE THAT GAVE TROUBLE

through the bypass to operate the engine, which was carrying about 66 per cent. of full load. After replacing the nut, allowing only ¼ in. play for the bypass opening, a new card was taken, showing a return to normal conditions. JOHN F. HURST.

Louisville, Ky.

Reliable Refrigation Data

Refrigeration is one of the growing branches of engineering as one can see by the yearly reports of sales of refrigerating apparatus or by the recent increase in the American Society of Refrigerating Engineers. On every hand we see new applications where its usefulness was unknown or neglected a few years ago.

This being the case, I want to appeal to *Power* and *Power* readers to assist in developing the art. Mechanical refrigeration is new; it is a growing subject and one relatively neglected. Very little reliable information is published, for in almost every case there is some personal motive in circulating the information, as in the celebrated horsepower per ton of refrigeration data. What the art requires is unbiased, up-to-date information on condensers, compressors, pumps and piping. It seems strange that such a simple piece of apparatus as an ammonia condenser should be so shrouded with secrecy as is at present apparent.

I therefore appeal to the operating and designing engineer to come forward and help those of us who would like to learn and cannot because of lack of available information. And I ask *Power* to make this possible by hearty coöperation in throwing open its columns to a general discussion on this very important branch of engineering. H. J. MACINTIRE.

Seattle, Wash.

Eliminating Cylinder Oil from Exhaust Steam

The manner in which W. H. Wakeman described the method employed in reducing the speed velocity of steam in the oil separator, page 365 of the Mar. 11 issue of *Power*, will probably be of assistance to others in eliminating oil troubles in their feed-water due to similar causes, but it would appear that the suggestions made to the engineer in charge, to the effect that the separator was not properly located, were correct.

According to most engineers the separator, in regular practice, should be placed between the engine and the heater so as to prevent oil from getting into the heater and coating the tube-heating surface and thus reducing the heat transfer of the exhaust steam to the water in the heater. The 12-in. connection between the heater and the separator could have been made between the 8-in. ell on the exhaust pipe and the separator just as well, and would probably have given just as satisfactory results and at the same time have prevented oil from entering the heater. L. A. HIGGINS.

Des Moines, Iowa.

Steam-Gage-Glass Marker

A marker of some kind is usually placed on steam gages, etc., when they are to be read from a distance or when it is desired to read them readily without going close up to see if the pointer is where it should be. Generally, an arrow or some such mark is painted on the gage, but a better plan is to paint the marker on the glass of the gage and then if at any time it is desired to change the point of reading, it will not be necessary to paint a new marker. Shifting the glass to the new position answers the purpose.

Norristown, Penn. WILLIAM H. WATSON.

Simple Tempering Method

Tempering a drill, cold chisel or other tool properly requires quite a knack, but there is a sure method that requires no skill. First heat the point of the tool to be tempered to a cherry red and then force it into a bar of lead, keeping it there for about half a minute. Then cool it in water. That is all there is to it.

To save the temper of a tool, as for instance an ax in which the handle has been broken off and the stub end cannot be driven out easily, drive the cutting edge of the ax into moist ground and then place live coals around the head. When the wood becomes charred, it can be driven out and the temper in the cutting edge will have been preserved. JAMES E. NOBLE.

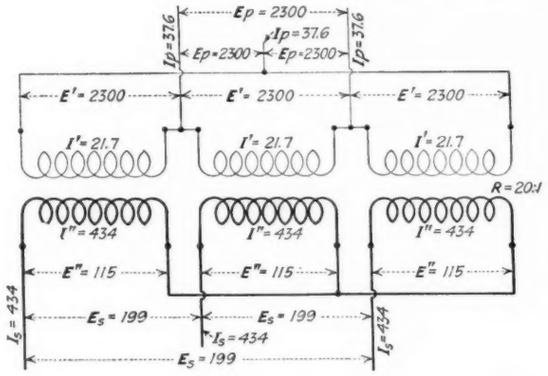
Kingston, Ont., Canada.

Prepare for Prosperity through the Victory Liberty Loan.

Inquiries of General Interest

Delta to Star Connected Transformers—When three single-phase 2300- to 115-volt 50-kv.-a. transformers are connected delta in the primary and star in the secondary, what will the voltage and current values be in the system when the transformers are fully loaded? J. G. B.

Since the primaries of the three transformers are connected delta, the voltage E' across the terminals of each transformer will be that of the line, or 2300 volts, and the secondary volts E'' of each transformer will be the primary



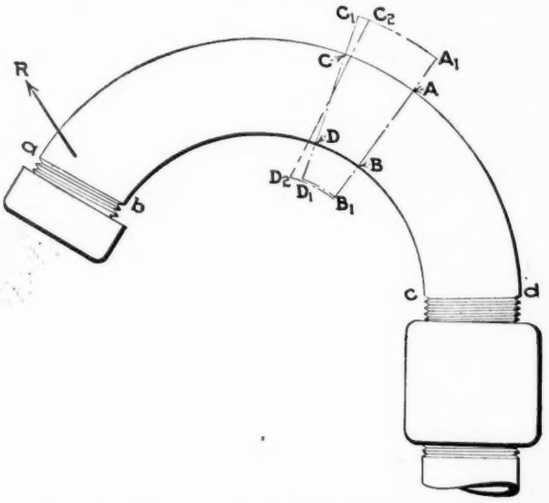
volts divided by the ratio. The ratio in this case is 2300 : 115, or 20 : 1. Then the secondary volts across each transformer $= \frac{2300}{20} = 115$. Since the secondary windings are connected in star, the voltage E_s between terminals is that of one transformer times $\sqrt{3} = (1.732)$, or $115 \times 1.732 = 199$ volts. The full-load primary current I' of one transformer will equal its full-load kv.-a. times 1000 divided by its primary voltage, or $50 \times 1000 \div 2300 = 21.7$ amperes. The primary windings are connected delta, therefore the current I_p per terminal will equal the primary current I' of one transformer times $\sqrt{3}$, or $21.7 \times 1.732 = 37.6$ amperes. In the secondary winding of each transformer the current I'' will equal that in the primary windings times the ratio, hence $I'' = 21.7 \times 20 = 434$ amperes. With the secondaries connected in star the current I_s per terminal is the same value as in the windings; that is, $I_s = I'' = 434$ amperes. The kv.-a. of the bank is the total capacity of the three transformers, or $50 \times 3 = 150$. The distribution of the current and volts is indicated in the figure. Of course these values are only theoretical; the loss of about 3 per cent. in the transformers will change the figures slightly.

Determining Belt Slippage—How can we tell when belts are slipping, and what instruments should be used to determine the percentage of slippage? A. B.

Serious slippage of a belt on a pulley usually is accompanied by a noise varying from a dull swishing to a sharp screeching. The only time that no slippage takes place is when the angular velocity of the belt, in passing around with the pulley, is the same as the angular velocity of the pulley. Assuming that the average lineal velocity of the belt is the velocity at the center of its thickness, normal belt velocity without slippage should be estimated as equivalent to the peripheral speed the pulley would have if its radius were equal to the actual radius plus one-half the belt thickness, or as if the diameter were equal to the actual diameter plus the belt thickness. There are excellent revolution counters on the market by which the r.p.m. is shown at sight. For determining the actual speed of a belt, use an instrument like a cyclometer, operated by a projecting finger attached to the belt, for counting the number of times per minute a point on the belt passes a stationary point to which the cyclometer is attached. The length of belt multiplied by the number of revolutions made by the belt per minute will give the actual belt speed per minute. This, divided by the peripheral speed that would be due to a driving pulley whose diameter is equal to the actual diameter plus the belt thickness will give the percentage of efficiency. The efficiency of the belt drive on the receiving pulley would be the peripheral speed due to the pulley diameter plus belt thickness, divided by the actual speed of the belt. For obtaining the total efficiency, multiply the r.p.m. of the follower by its diameter plus the belt thickness and divide by the product of the r.p.m. of the follower pulley and its diameter plus the belt thickness. In any case the percentage of slippage would be 1 minus the percentage of efficiency.

Action of Bourdon Pressure-Gage Spring—What causes the bent tube spring of a Bourdon pressure gage to straighten out for pressure and become more curved for a vacuum connection? C. W.

Suppose *abcd* to be a bent pipe of any cross-section, made of elastic material and having a free end *ab* stopped



off, and subjected to internal pressure of steam or air introduced at the supported end *cd*. When inflated, the pipe would expand in diameter, and by sufficient pressure a point like A would have a tendency to move outward radially to a position A_1 and a point at B would have a tendency to move radially to a position B_1. In the same manner there would be a tendency to carry the point C to C_1 and D to D_1. But for actual radial movement the distance C_1 to A_1 would need to be greater than CA, and D_1B_1 would be less than DB, and if the material around the outer curve of the bend was not sufficiently elongated, or the material along the inner curve was not sufficiently compressed, the material originally located along the section CD would assume a sloped position like C_2D_2. Hence for increase of internal pressure the free end of the tube would be carried upward in the direction of the arrow R by the cumulative action of succeeding sections, or in other words, it would become straighter; while for a vacuum or collapsing pressure of the atmosphere, the curvature would be increased because the bending forces would be the reverse from those resulting from inflation. For greater sensitiveness the spring tubes of Bourdon pressure gages are flattened or elliptical in cross-section, with their shorter axis normal to the curvature of bend.

Fusion in Arc Welding*

By O. H. ESCHHOLZ

Calls to attention such characteristics as penetration and overlap, peculiar to the metallic-electrode arc-welding process, which facilitate visual inspection, and discusses briefly the effect of arc length, welding procedure, electrode material, arc current and electrode diameter upon these characteristics.

THE physical characteristics of a weld are admittedly determined chiefly by the degree of fusion secured between adjacent metals. In the production of welds by the metallic-electrode process, a fair estimate of the fusion may be obtained by an examination of the surface of the deposited metal and the depth of the arc crater formed when welding at normal speed. These observations give an adequate indication of the two prime characteristics of fusion—penetration and overlap—which, however, are definitely revealed only on exposing a section through the zone fusion.

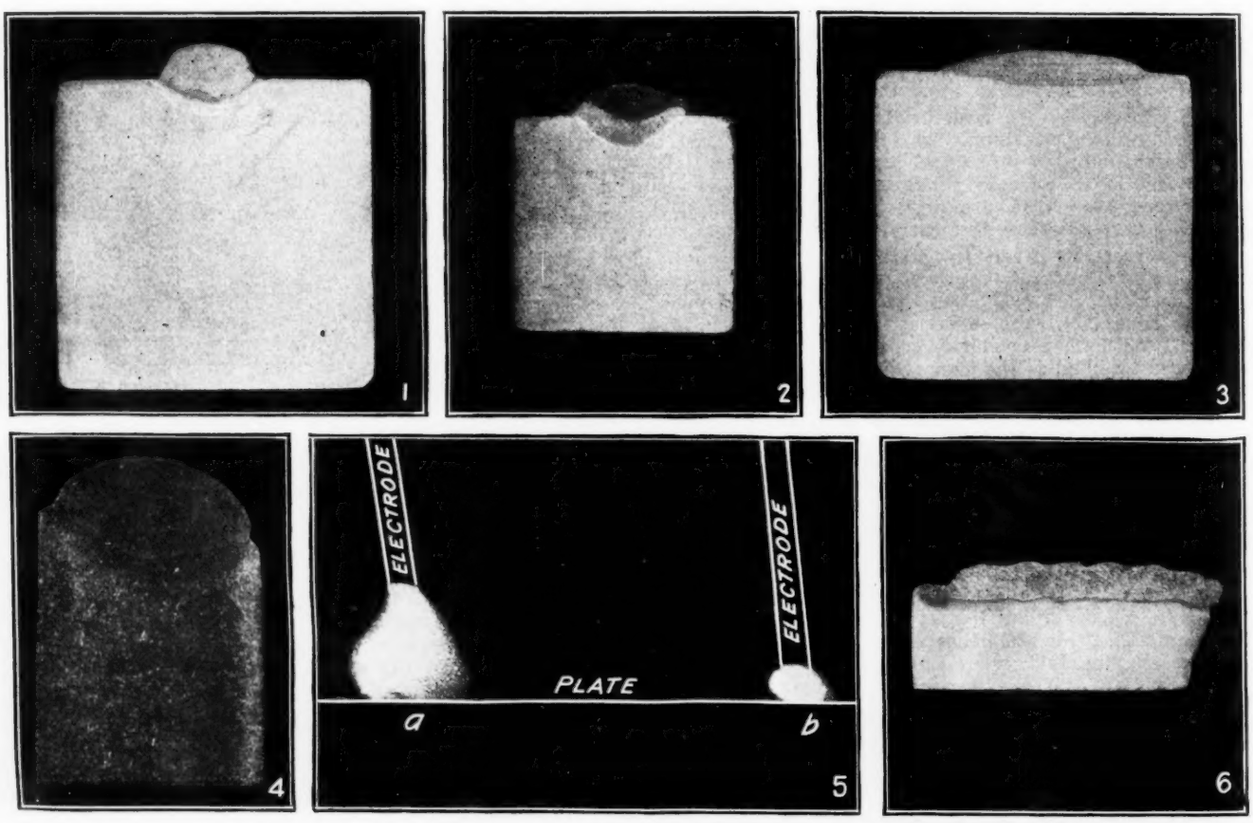
Figs. 1 and 7 illustrate the union between a layer of metal deposited from a low-carbon steel electrode upon a low-carbon steel plate. The line of demarcation between the plate and deposit indicates the zone of fusion, the polished and etched surface of the deposited material presenting a different appearance, due to its crystalline structure, from that of the plate material. Two characteristics are at once apparent—a penetration of the deposited metal into the plate metal over almost the entire width of the layer, and a slight overlapping upon the plates without fusion of the extreme edges of the deposit. The penetration is due to liquefying of the plate metal by the energy absorbed from the arc as well as that absorbed from the molten deposit.

At the center of the deposit, where both effects are present, the penetration is greatest; at the extreme edges, however, where the deposit has overflowed the area included by the arc crater, the energy liberated on cooling is insufficient to melt the plate metal and the deposit congeals without fusing to it. It is typical of such overlapping that the edges of the deposit are well rounded, a distinct gap often existing between the plate and edge of deposit. The convex of the deposit thus forms a reentrant angle with the plate edge. To insure satisfactory fusion a proper degree of penetration should be obtained with no overlap.

Figs. 2 and 8 show a section through the crater obtained on breaking an arc during the process of depositing a layer of metal on a steel plate. It may be observed that the depth of the crater depression is comparable to the depth of penetration of the deposited metal below the plate surface. A simple visual indication is, therefore, available during the welding operation for gaging the penetration.

The convex edges of the deposit shown in Fig. 2, par-

*Paper presented at a joint meeting of the American Institute of Electrical Engineers and the American Institute of Mining Engineers, held during the Midwinter Convention of the American Institute of Electrical Engineers, New York City, February, 1919.



FIGS. 1 TO 6 PHOTOGRAPHS OF SECTIONS THROUGH ELECTRIC-ARC WELDS

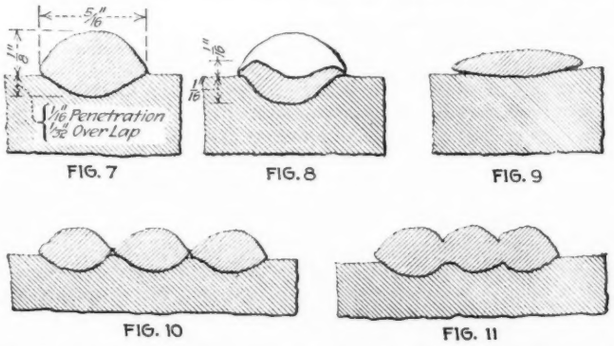
Fig. 1—Section through a layer of metal deposited on a mild steel plate, when using a short arc and a proper welding current. Fig. 2—Section through the crater remaining on interrupting the arc current. Fig. 3—Section of deposit obtained with a long arc, indicating excessive overlap and practically no penetration. Fig. 4—Absence of overlap when depositing metal of a high-melting point on a plate of low-melting point. Fig. 5—(a) Long arc. (b) short arc. Fig. 6—Section through the center of a deposited layer in the direction of forming the deposit.

ticularly evident at the right of both Figs. 1 and 2, would lead one to expect an appreciable overlap. This is disclosed on a careful inspection of the sections, Figs. 7 and 8. A surface contour with no overlap is shown in Fig. 4. This condition is usually typified by the absence of even the smallest reëntrant angle, an intimate contact between plate and deposit being secured, the junction between the two metals often forming a concave surface.

A condition of extreme overlap is shown in Fig. 9. This is typical of a low-melting point electrode or of too great speed of arc travel. The convex deposit edge and the reëntrant angle between it and the plate are pronounced.

The effect of fusion of arc length has been discussed at considerable length by welding engineers. Some assert that better fusion is secured for a given arc current with a long arc than with a short arc, owing to the greater amount of energy absorbed by the arc; others have stated that the degree of fusion is dependent solely on the arc current and, of course, the thermal characteristics of the metal welded. For a given arc current it has been the author's experience that fusion is not improved with increase in arc length, that the best weld characteristics are obtained when holding a short arc, not longer than $\frac{1}{8}$ in. and preferably about $\frac{1}{16}$ in. With a given arc length the ease of securing complete fusion increases with arc current until a maximum value is reached beyond which further increase results in a weakened weld structure.

Figs. 1 and 3 are typical of sections through deposits formed with a short and a long arc respectively, the arc



FIGS. 7 TO 11. SECTIONS THROUGH METAL DEPOSITED BY THE METALLIC ELECTRODE PROCESS

current being approximately the same in each instance With a short arc the plate metal is liquefied by the energy required to maintain the arc crater, by that conducted from the arc flame in constant intimate contact with the plate and by the energy radiated from the arc stream and electrode terminals, as well as by that absorbed from the molten-electrode deposit. When the molten material passes through a short arc it is quite completely enveloped by hot gases and suffers but slight loss in temperature before being deposited. Upon drawing a long arc the air currents in its vicinity blow the arc stream and arc flame about violently, so that it is difficult to maintain the plate terminal of the arc in a given position long enough to effect sufficient penetration. Moreover, the energy absorbed from the arc stream and electrode terminal becomes practically negligible, due to the greater diffusion of the radiation in the region of the arc plate terminal, while the energy absorbed from the molten metal is decreased because of the loss in temperature the deposit has sustained in transition. Some conception of the appearance of short- and long-arc lengths may be obtained from Fig. 5.

The extreme condition of no overlap is difficult to secure when depositing a single layer of electrode metal upon the usual low-carbon steel plate. For most purposes a slight overlap, such as indicated in Figs. 1 and 7, is permissible in single layers as a simple procedure of depositing the subsequent layers will fuse the overlapped areas.

Fig. 10 illustrates the characteristic penetration and overlap when parallel abutting layers are formed. The minimum overlap for this condition will approach $\frac{1}{16}$ in. per layer. If the width of a layer is increased by weaving the electrode back and forth, the percentage overlap will be decreased. However, it may be eliminated by the simple expedient of always overlapping adjacent layers as shown in Fig. 11. On forming the second tier of deposits, the same precaution should be taken to prevent unfused zones. Fig. 6 shows a typical section through the center of a layer. It may be noted that although the depth of penetration varies somewhat, owing to the speed of arc

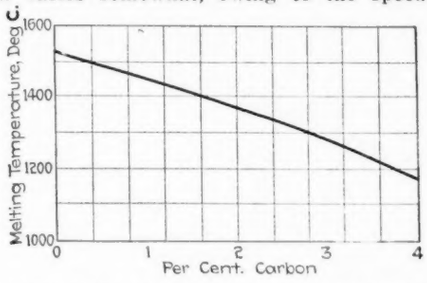


FIG. 12. MELTING POINTS OF IRON ALLOYED WITH VARIOUS AMOUNTS OF CARBON

travel and unavoidable variation in arc length, good fusion has been secured between the plate and deposit along the entire length of the deposit.

Since the choice of electrode material, arc current and electrode diameter largely determine, with a given manipulative skill and welding procedure, the depth of arc crater and deposit contour, a brief discussion follows of such characteristics, which affect fusion between the deposit and plate metals.

To minimize the occurrence of unfused areas, the melting point of the electrode metal should exceed that of the plate metal. Fig. 1 illustrates the fusion obtained with the melting points approximately equal (0.18 per cent. carbon, 1510 deg. C. approx.), Fig. 4 that secured with a greater melting point for the electrode (0.18 per cent. carbon, 1510 deg. C. approx.) than for the plate (3 per cent. carbon, 1280 deg. C. approx.), and Fig. 9 that obtained with a lower electrode melting point (1.1 per cent. carbon, 1440 deg. C. approx.). The melting point of most weldable steels may be gaged with sufficient accuracy for welding purposes by the carbon content, as shown in Fig. 12. The usual additions of other alloying ingredients reduce the melting point a negligible amount.

While pure iron possesses the highest melting point, its use is not advisable since excessive oxidation of the vaporized metal occurs. However, a commercially pure iron alloyed with about 0.18 per cent. carbon and 0.5 per cent.

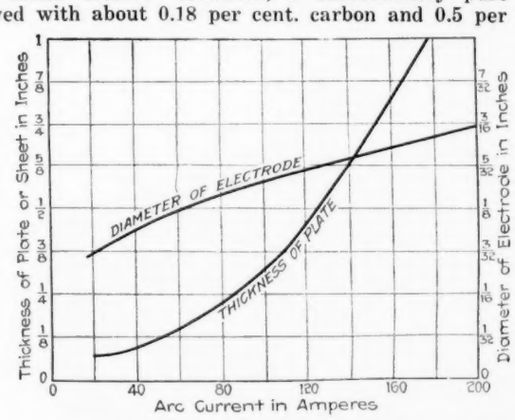


FIG. 13. APPROXIMATE VALUES OF ARC CURRENT AND DIAMETER OF ELECTRODES

manganese greatly reduces the oxidation and improves the ease of manipulation without an appreciable sacrifice in melting point. For most purposes the use of this electrode gives a reasonable minimum overlap.

Under exceptional conditions such as high thermal capacity of weld, or overhead welding with a low current, the overlap may be excessive even when using this elec-

trode; it is customary then to preheat the object to be welded or to adopt a welding procedure which utilizes the thermal energy from preliminary welding operations to raise the temperature of the object welded.

For a given plate thickness the welding current will vary with the type of weld scarf, cleanliness of surface, thermal capacity and conductivity of the metal, and position of plate with respect to the welder. The values shown in Fig. 13 apply only to clean, butt-welded plates, single V,

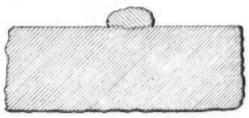


FIG. 14. FUSION SECURED WITH TOO LOW ARC CURRENT

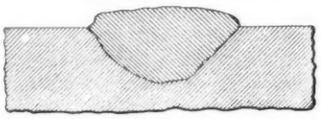


FIG. 15. FUSION SECURED WITH TOO HIGH ARC CURRENT

scarfed to 90 deg., supported in a horizontal position below the welder, in poor thermal contact with any metal of high thermal capacity. The fusion obtained with too low and too high arc currents is shown in Figs. 14 and 15 respectively. In Fig. 14 the overlap is excessive and the penetration unsatisfactory because of the small amount of energy applied at the arc crater. In Fig. 15 the excessive energy consumption at the plate arc terminal produces excessive penetration, a further increase in current permitting cutting through the plate.

Fig. 16 indicates approximately the effect of variation of arc current on fusion and therefore on weld strength for (curve *A*) skilled and (curve *B*) unskilled welders. Weld structures are occasionally encountered in which variations in thermal capacity and plate temperature necessitate changes in arc current if complete fusion is to be secured. Observations of the deposit contour and crater depth usually serve to indicate to the operator when such changes are advisable.

A close adjustment of electrode diameter to arc current is not essential. For miscellaneous direct-current welding the densities usually fall within a range of 7000 to 10,000 amperes per sq.in. if an 0.18 per cent. carbon-steel electrode is used. However, whenever practicable, the author prefers a closer range of 8000 to 9000 amperes per sq.in. With too great an electrode diameter for a given current,

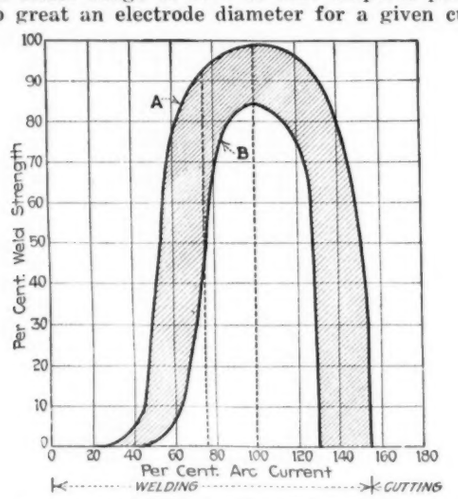


FIG. 16. CHANGE IN WELD STRENGTH WITH CHANGE IN ARC CURRENT

the arc becomes more unstable, increasing the manipulative skill required and decreasing the rate of depositing electrode material. Too small a diameter causes a deposition of electrode material before the plate has been properly liquefied; it also results in overheating and softening of the electrode, which increases the skill required to prevent the electrode from "freezing" to the plate. With the correct diameter the electrode material is sprayed in a regular stream at a rate that will insure maximum welding speed consistent with good fusion.

For example, the characteristics of fusion and the effect of a control of the conditions that govern them may be summarized in comparing the procedure for making butt and lap welds.

In butt-welding $\frac{1}{2}$-in. low-carbon steel plates, scarfed as shown in Fig. 17, a $\frac{3}{32}$-in. diameter welding electrode containing approximately 0.18 per cent. carbon, 0.5 per cent. manganese, would preferably be used with an arc current of approximately 150 amperes. With moderate skill the strength of weld should approximate 90 per cent. that of the plate. If the same current and electrode diameter are used in welding the lap joint formed from $\frac{1}{2}$-in. plates shown in Fig. 18, poor fusion will be obtained owing to the increased thermal capacity of the abutting sections. As shown in Fig. 18 the penetration will be too slight and the overlap excessive, similar to the case shown in Fig. 14. In fact, sections through completed lap joints most invariably show that in forming the first deposit, which is the most important, even expert welders tend to penetrate only one side of the weld scarf with resultant overlap on the other. Breakdown tests of lap joints have plainly shown failure due to this cause.

To secure complete fusion on both faces of the joint, it is necessary to increase the arc current and with it the

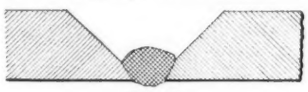


FIG. 17

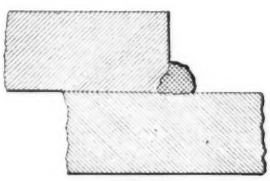


FIG. 18

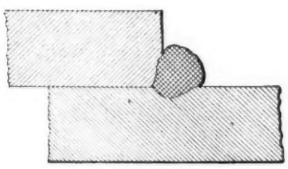


FIG. 19

FIGS. 17 TO 19. SECTIONS THROUGH BUTT AND LAP WELDS MADE UNDER DIFFERENT CONDITIONS

electrode diameter. For the condition shown in Fig. 19 an arc current of 225 amperes and an electrode diameter of $\frac{3}{16}$ in. was found to produce complete fusion, facilitate electrode manipulation and increase rate of electrode deposition.

In conclusion it may be said that the fusion obtained in arc-welded joints between the plate and deposit metal is determined by the penetration of the deposit metal into the plate metal and the overlap of the edge of the deposit layer on the plate. The penetration is comparable to the depth of arc crater as observed by the welder when moving the arc terminal over the plate with uniform velocity, and the overlap is indicated by the contour of the surface of the congealed deposit in the region adjacent to the material welded. For most welds a crater depression of $\frac{1}{16}$ in. will give the desired penetration, while a contour that does not show a reëntrant angle between plate and deposit indicates an overlap per layer of approximately $\frac{1}{32}$ in. or less.

The Engineer as a Citizen

Under the auspices of the local sections of the several national engineering societies a symposium was held on Wednesday evening, Mar. 26, in the Engineering Societies Building, New York, to discuss how engineers individually and collectively might take a more active part in public affairs. The program included addresses by half a dozen engineers prominent in the fields of electrical, mechanical, mining and municipal engineering, and was followed by discussion of a profitable nature.

Gano Dunn, past president and fellow of the American Institute of Electrical Engineers, presided and after a short introductory address touching upon the need for engineering council in these times, called upon Philip N. Moore, past president of the American Institute of Mining Engineers, whose topic was "The Civic Responsibility

of the Engineer." "Present conditions as regards the engineer's relation to public affairs," said the speaker, "are traceable largely to past indifference to political activities and civic duties." This indifference he attributed to several causes, among which were lack of local attachments, business connections sometimes adverse to public interests, too technical training, and the habit of keeping aloof. The remedy for this isolation lay primarily within the engineer himself and secondly within the societies. Touching upon present economic conditions the speaker urged that brains must always rule brawn; that labor, if it would share in profits, must also be ready to share in losses; and that at no time has there been greater need for engineering thought and clear reasoning to offset unsound reform.

The next speaker, Calvert Townley, discussed "The Relation of the Engineer to Legislation." He referred to the American Institute of Electrical Engineers having been called upon for technical advice on water powers by Congress on several occasions; the effective work of the engineering societies in blocking dangerous license legislation at Albany in 1911; and finally activities that led up to the formation of the Engineering Council.

Nelson P. Lewis next spoke, on "The Relation of the Engineer to Administration." Positions requiring administrative ability, he observed, were once filled only by business men and lawyers, but in recent years the technically trained man is coming more and more into these positions. Commission form of government and the growing popularity of the city-manager idea has also opened a field for the engineer with executive ability. There are now 124 cities or towns in the United States that have city managers. The speaker was able to give particulars concerning eighty-eight of these and out of the eighty-eight the managers of fifty were professional engineers.

Spencer Miller, speaking for the mechanical engineers, was of the opinion that men of technical training are occupying positions of ever-increasing responsibility in public life; that public opinion, while not always right, is always autocratic; and that there is great opportunity for engineers as a class to help mold public opinion in the right direction. "Morale," said the speaker, "is as essential as technical training." Therefore the engineering societies should encourage the establishing of morale and should begin with a simple code of ethics, which should be rigidly enforced and which should be a requisite for admission to membership in the societies.

The last speaker on the program, Prof. Comfort A. Adams, prefaced his address by reference to engineering education, in which he emphasized that the subjects taught were secondary to how they were taught and by whom taught, and that this had great influence upon the success of the student in later life. Touching upon present economic conditions, he expressed the belief that there is too much destructive competition and pleaded for greater coöperation in the various industries.

Industrial Personnel Relations

On Mar. 24 the Chicago sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and the Western Society of Engineers held a joint meeting at the rooms of the society last named. The attendance was the best of the season and the topic "Industrial Personnel Relations" one of particular interest at the present time. Introductory to the paper of the evening a moving picture, "The Outlaw," depicted to the audience the various causes of injuries to employees in industrial establishments and the methods employed to reduce the number of these accidents.

A. H. Young, manager of the Industrial Relations Department of the International Harvester Co., traced briefly the development of safety engineering and spoke of his former work with the Illinois Steel Co. along these lines. He said that the remarkable success of their efforts had really instigated the great safety movement of today, that accidental deaths of employees, ranging from 47 to 56 per year, had been reduced to 7 in 1913 and minor accidents in proportion; that through it all, including all expense attached to the safety movement, the company had been the gainer financially.

On the topic of the evening Mr. Young was intensely interesting. He compared the old haphazard methods of employing men with the centralized employment office, reviewing in particular methods used by his company. They now take three to three and one-half days to put men on the payroll as compared to three minutes in the old days. The employee is made to feel that he is a real part of the organization, hired to do the particular job for which he is best adapted. Moving pictures instruct him as to how the work is to be done. He is also instructed specifically by the foreman and is warned of the various dangers connected with the work. He is shown the best entrance to the plant for his department and is helped to find a home convenient to his work.

The threat of Bolshevism is due largely to not letting the men in on the "know." When the men fully understand the trade conditions in the field, the policy of the company and the reasons for doing certain things, the likelihood of a misunderstanding has been reduced.

An interesting experiment is the new arrangement the company is now making by which all matters of mutual interest are passed on by a works council, of which 50 per cent. are employees and the other half representatives of the employer, such as superintendents. This council determines the policy and the management carries it out. In this way the men are educated in the problems of management, they see and understand the difficulties, and have already shown signs of being fair and reasonable in the problems they have had a part in solving.

Progressive plans that have been adopted by Montgomery Ward and the Republic Flow Meters Co., were outlined in the discussion following the paper. Numerous other speakers indicated the interest that engineers are taking in one of the greatest world questions of the day.

Babbitt Metals and Solders*

By Alfred A. Greene

What is babbitt metal? You may be surprised to know that there is only one babbitt metal and that is the formula compounded by Isaac Babbitt about sixty years ago, for which Congress gave him a gold medal and $50,000. It is composed of 88.9 per cent. of tin, 3.7 per cent. of copper and 7.4 per cent. of antimony. The fact that he died in an insane asylum does not detract from the merits of his formula, because it has been the standard for high-grade antifriction metal for many years. All other lining alloys have been attempts to improve this formula in its physical characteristics or reduce its price. By custom these have been called babbitt metals, even though they contain no tin or copper, but, like No. 4 babbitt, consist of lead and antimony.

What are the physical characteristics of the elements that compose a lining alloy? Let us take genuine babbitt for our illustration. Tin is a crystalline metal, is very malleable and takes a high polish, but it would be too soft to use as a bearing. The addition of 7 per cent. of antimony makes it harder and gives it compressive strength, but also increases its brittleness, so copper must be added to give it toughness and tensile strength. The addition of 7 per cent. of antimony and 4 per cent. of copper to 89 per cent. of tin brings up the Brinell hardness to about 28 or over three times as hard as pure tin.

Lead as an Antifriction Metal

Now, while tin and antimony are antifrictional, yet they are not the best antifrictional metals. Nature has given us lead, which is oily and greasy and is the best metal for antifrictional purposes; but unfortunately pure lead is very soft and by itself has no value as an antifriction metal. Unfortunately again, it is very hard to alloy other metals with lead. For instance, it is impossible to make a true alloy of lead and copper. I fully appreciate the claims that are made for the leaded bronzes, but I have yet to see an alloy of lead and copper, no matter how carefully made, that will stand remelting without segregation. This is

*Abstract of an address made before the Purchasing Agents Association of St. Louis, Feb. 18.

because there is no affinity in the metals. On remelting this metal, the lead sweats out and settles to the bottom. This is what prevents its use as a lining alloy.

Lining-alloy manufacturers, recognizing the value of lead as an antifriction metal, have tried to use as much lead as they could, which has brought about a series of alloys ranging from 92 per cent. of tin and no lead, down to 95 per cent. of lead and no tin. It is a well-known fact that a purchasing agent can always buy a babbitt metal at his own price. This can be readily understood when the prices of the metals are taken into consideration. With tin selling at 75c. a pound and lead at 5c. a pound, it is only necessary to take out 2 per cent. of tin and add 2 per cent. of lead to make a difference of 1½c. a pound, and it is almost impossible to tell from examination of the metal that it contains the 2 per cent. of lead. This may not work any harm from a service standpoint, because it is a fact that in the use of most of the lining alloys there is a great factor of safety, but it is not the proper way to do business.

Fundamental Requisites of a Bearing Metal

There are four fundamental requisites in a lining alloy: Compressive strength, tensile strength, heat resistance and antifrictional qualities. You will notice that I have placed antifrictional qualities last. It is generally understood that antifrictional qualities are the most important, but this is not so. A lining alloy to be of value must first have compressive strength; that is, it must be able to hold up the maximum load per square inch that is liable to be put on the bearings without squashing out. It must have sufficient tensile strength so that if the bearings are subjected to vibration or pounding it will not break apart. It must have sufficient heat resistance so that the alloy will stand the greatest possible heat before beginning to flow. Without these three qualities, the quality of antifriction has no great value. As a matter of fact, under ideal conditions the shaft never touches the babbitt metal. There is supposed to be a film of oil between the babbitt metal and the shaft all the time and this is what the shaft actually rides upon. It is when the oil film is not maintained that the antifrictional qualities of the metal become of real importance.

Genuine babbitt, which has been the standard for so many years as the best metal that could be produced for the most severe service, has certain physical characteristics. It is 28 Brinell hard, has an elastic limit of 10,000 lb. and a tensile strength of about 11,000 lb. Now, if the bearing-metal manufacturer can prove that it has the same physical characteristics, it really makes no difference to you from what the alloy is made, provided it is sold to you at an attractive price. Genuine babbitt contains 89 per cent. of tin and no lead; yet there is a concern in this country that has produced a metal which is the equal of genuine babbitt in tensile strength, compressive strength and Brinell hardness, has greater heat resistance and much better antifrictional qualities and yet it does not contain any tin, copper or antimony.

New Metal an Electrically Hardened Lead

It is an electrically hardened lead, with a very small percentage of other ingredients added, which have never before been used in babbitt metals. The process of manufacture takes several days to attain the desired result, and while the cost of manufacture is very much more expensive than any other babbitt, there still is an enormous saving when compared with tin-base alloys. The Bureau of Standards has made a series of tests and has issued a report showing that the metal has a tensile strength of 13,000 lb. and an elastic limit of 11,525 lb.; and in a running test on bearings at 1000 lb. per sq.in., load running at 400 r.p.m., the final temperature was only 150 deg. The following is a quotation from the report: "This metal possesses all the requisites of a good bearing; namely, hardness, compressive strength, low friction, heat resistance and low cost." This metal was born of necessity. Due to the war tin became very scarce and the Government requested that every effort be made to conserve it. As a result of scientific research work on original lines this metal was adopted.

The question is often asked if just as good babbitt metals can be made from scrap metals as from new metals. The answer is, good babbitt metals can be made from scrap metals; but it is not true that on exactly the same formula they are as good as they would be if made from new metals. The lining alloys made from scrap metals may do the work satisfactorily, because of the usual factor of safety, but although they are sold at a lower price they are not any cheaper. This is due to the fact that every time metals are melted a certain amount of oxidation takes place. If scrap metals are used, the oxides are present and in the ordinary shop practice they cannot all be eliminated. These oxides come to the top when the metal is melted and are skimmed off in the form of dross. This means that you do not get as many pounds of metal in your bearings when made from scrap as you would of the same formula made from new metals. Again, the physical structure of the metals is weakened when scrap metals are used. For instance, old lead pipe may contain lime, potash, sulphuric acid or any number of things. The impurities cannot be removed by just melting the lead in a pot. A chemical reaction has taken place in the lead, and it has lost its original characteristics. You cannot expect it to have the same strength as pure lead. If scrap tin is used, the same arguments apply as to lead. In the process of taking tin coating from tin cans, you are likely to get some iron oxide, and a small amount of iron will destroy a babbitt metal.

In regard to solders, practically the same arguments apply as in babbitt metals. We should be able to tell you the proper formula to use when you tell us what you want to do with the solder. We know that solder is made from tin and lead. Certain combinations produce certain results. As you cut down in tin and increase lead you raise the melting point and lose fluidity. Strange things happen in combinations of metals. For instance, tin melts at 450 deg. F. Lead melts at 628 deg. F. Theoretically, a mixture of 50 per cent. of tin and 50 per cent. of lead should melt at 540 deg. F. Actually, it melts at 398 deg., which is lower than the melting point of either of the metals that compose it. This means that with a 50-50 solder you get great fluidity at low temperatures. Therefore, a man can cover a greater surface in less time and use less solder than if he were compelled to use a solder which was more sluggish, and would have to change his irons more frequently, and could not make as thin a seam. A purchasing agent can save money on the cost of the solder by buying one that contains less tin, but if by so doing he increases the time of the job, and uses more pounds of solder, there is no real economy.

Blowing Down Water Columns

The low-water and high-water alarms on a good many of the water columns at the steam plants are operated by floats, designed to withstand a high static pressure.

Not only has the failure of these floats due to collapsing been the cause of a maintenance item of appreciable loss, but it has caused the boiler to be left without the protection of the water alarms from the time of the failure, which is in most cases shortly after the boiler is placed on the line, until the boiler is down for cleaning and repairs. So from a safety as well as a maintenance viewpoint steps should be taken to prevent the failure of these floats.

Floats will not fail if the water tender follows out the following instructions:

When blowing down water columns, observe the following precautions:

Open up the blowdown valve slowly. If there are two valves in this line, open the valve nearest the column—wide. Then open the second valve slowly.

Close the blowdown valve slowly. If there are two valves in this line, close the valve farthest from the column, slowly first, then close the remaining valve.

Under no conditions open and close the blowdown valves quickly for the purpose of causing the water in the glass to bob up and down. At times of low water, water tenders who operate their blowdown valves in this manner so as to determine approximately how low the water is, may cause a collapsed float.—*Au Sable News.*

Personals

William B. Symmes, Jr., solicitor of the United States Fuel Administration, has announced his resignation. His release was executed by Fuel Administrator Harry A. Garfield at Mr. Symmes' urgent request to be permitted to resume the practice of law in New York, where he is a member of the firm of Davis, Symmes & Schreiber.

F. R. Still, vice-president and secretary of the American Blower Co., has left on an extended trip for the Far East, where he will investigate trade conditions in connection with export work. Mr. Still's itinerary includes Japan, China, Australia and most of the European countries, and he expects to cover approximately 36,000 miles before returning home about Nov. 1.

Capt. A. C. Nell, who was in charge of the purchase of power and mechanical equipment in the construction division, U. S. A., for the period of the war, has been released and has been appointed Chicago district manager for the Lea-Courtenay Co. and the Schütte & Koerting Co., with offices at 1466 Conway Building. Mr. Nell was formerly with the Allis-Chalmers Manufacturing Co.

Engineering Affairs

The Association of Iron and Steel Electrical Engineers, Philadelphia Section, will hold a meeting on Apr. 5. H. B. Vincent, operating engineering with Day & Zimmerman, Inc., will talk on "Power Transmission."

New York Engineers' Protective Society will give their next lecture, "Heating and Ventilating," in their Lodge Rooms, Hall No. 3, Bloomingdale Building, 60th St. and Third Ave., at 8 o'clock, Saturday evening, Apr. 5. These lectures are given for the education and entertainment of the younger members of the trade. All engineers are welcome whether members of the organization or not.

The Tenth Annual Engineers' Dinner of the American Society of Mechanical Engineers, American Institute of Electrical Engineers and the Boston Society of Civil Engineers will be held in Boston at the Boston City Club on Apr. 2. The following, as well as other societies, will participate: American Chemical Society, American Institute of Mining Engineers, American Society of Civil Engineers, Engineers' Club, Illuminating Engineering Society, New England Water Works Association, Plant Engineers' Club, American Society of Heating and Ventilating Engineers.

Miscellaneous News

The Compressed Gas Manufacturers' Association, Inc., has moved its offices from 120 Broadway to Rooms 1216, 1217, 23 E. 26th St., New York City.

Three Men Were Slightly Burned and others injured when the furnace of a Scott marine-type boiler failed in the basement of the Corbett Building, Portland, Ore., on the morning of Mar. 13. The boiler was all fired, and the burning oil scattered by the explosion of the steam added to the seriousness of the accident.

The Engineering Advertisers' Association was organized recently at a meeting held at the LaSalle Hotel, Chicago. Some of the leading manufacturers of engineering products were represented, a constitution and by-laws adopted and officers and directors elected. Regular meetings of the association will be held monthly excepting during July and August, at which speakers of recognized prominence in the field of engineering advertising will give addresses, and free discussion will be given the various problems that arise in it.

National Association of Corporation Schools and the United Engineering Society, representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, will give employers and others interested in personnel work an opportunity to examine the methods developed by the Committee on Classification of Personnel in the Army at an exhibit to be shown on the third floor of the Engineering Societies Building, 29 West 39th St., New York City, April 1-12. The exhibit consists of a collection of wall charts, forms, photographs and models showing how the Army finds out what men can do best and how it uses that information; how soldiers are trade tested and how officers are rated and fitted into place; how the work is checked and supervised and its results in the war. It was on exhibition for several weeks at Washington, where it excited so much interest that in response to many requests the Adjutant General consented to its display in other cities. Two commissioned officers accompany the exhibit to explain its various features.

Business Items

The Archiable Electric Co., Inc., has been formed and is now doing business in electrical construction and wiring at 138 West Third St., Cincinnati, Ohio, with George W. Archiable as president and manager and W. E. Retsch as secretary and treasurer. Both men are well known to the trade in that territory.

The Chicago Pneumatic Tool Co. announces the following changes in its personnel: It has opened offices and warehouses at Tulsa, Okla. (313 Richards Building) and at El Dorado, Kan.; The Boston (Mass.) office of the company has been removed to 182 High St. with F. S. Eggleston, district manager of sales, representing the company's interests in this territory. J. I. Edwards has been appointed manager of the rock drill sales division, succeeding E. Eklund, who has been appointed special foreign representative and will leave shortly for Europe in the interests of the company; Fred H. Waldron, formerly Minneapolis representative of the company, has been appointed manager of the pneumatic tool sales division succeeding J. G. Osgood, resigned. Mr. Waldron's offices are now at the company's headquarters in the Fisher Building, Chicago; Nelson B. Gatch was recently appointed district manager of sales for the company at Minneapolis with offices at 301 Metropolitan Bank Building; J. K. Haigh has been appointed assistant district manager of sales for the company's San Francisco office at 175 First Street.

Trade Catalogs

Reilly Multisereen Feed Water Filter and Grease Extractor. The Griscom-Russell Co., New York City. Bulletin 609. Fully describing this type of apparatus. Copy free upon request.

The Automatic Reclosing Circuit Breaker Co., of Columbus, Ohio, has issued Bulletin No. 301 describing its new types of breakers, "ARL," "DRL" and "CRL." A copy may be had upon application.

The Coatesville Boiler Works, of Coatesville, Penn., has issued a very instructive and attractive 96-page cloth-bound catalog, No. 24, on steel tanks, boilers and stacks, A. S. M. E. boiler specifications, stock sizes of A. S. M. E. return-tubular boilers, and other heavy steel-plate work.

The Quigley Furnace Specialties Co., Inc., New York City, has issued Bulletin No. 11, which describes the equipment employed in the Quigley system for preparing distributing and burning powdered fuels. It describes a method which has been in successful operation for many months on a variety of furnaces and was developed as the result of 20 years' practical experience in selection and application of fuels and in furnace design and operation.

The Westinghouse Electric and Manufacturing Co., of East Pittsburgh, Penn., has issued a complete catalog in which all of its electrical supplies are listed. Every effort was exercised to make the catalog of the greatest convenience to purchasers. It is made up of 1264 pages of description pertaining to the products of the company and a score of other pages containing a complete cross index, an index to style numbers, and a table of "Approximate Cost Multipliers" which enables one to figure the approximate cost of all supplies listed. The book is more than a catalog in that it contains much information of a technical and engineering nature. Practical suggestions for the use of many kinds of apparatus for the transmission and utilization of electric power are given. It is planned to issue this catalog annually.

New Construction

PROPOSED WORK

R. I., Westerly—The city approved $300,000 bond issue to purchase or construct a lighting plant. E. E. Whipple, City Clk.

Conn., New Haven—A. L. and I. Adelman, 10 Garden St., will install a steam heating plant in the 5-story apartment hotel which it plans to build on Whalley Ave. Total estimated cost, $165,000. J. Weinstein, 6 Church St., Arch.

Conn., Stratford—The Raybestos Co., Bostwick Ave., Bridgeport, will install a steam heating plant in the 1-story, 160 x 170 ft. factory which it plans to build on East Main St. Total estimated cost, $100,000.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, will install a steam heating plant in the 4-story, 100 x 144 ft. P. S. No. 100 which it plans to build on West 1st St. Total estimated cost, $299,500. C. B. J. Snyder, Municipal Bldg., New York City, Arch.

N. Y., Lyons—The Lyons Cold Storage Co. will install artificial ice making machinery in their Rankert plant to make 15 tons of ice daily. Estimated cost, $12,000.

N. Y., New York—The Italian Savings Bank, Cleveland Place and Spring St., will install a steam heating plant in the 10-story, 100 x 150 ft. bank which it plans to build. Total estimated cost, $150,000. C. P. H. Gilbert, 1123 Bway., Arch.

N. Y., New York—Musher & Co., 140 Liberty St., will install a steam heating plant in the 12-story, 49 x 100 ft. store and loft building which it plans to build at 255-257 5th Ave. Total estimated cost, $190,000. S. B. Eisendrath, 18 East 41st St., Arch.

Md., Middletown—The Middletown Packing Co. is in the market for boilers, pumps, shafting, pulleys and electric motors, to be installed in the factory and warehouse which it plans to build. Total estimated cost, between $6500 and $7000.

Md., Sollers Station (Sollers P. O.)—The Aluminum Ore Products Co., Inc., 800 Maryland Trust Bldg., Baltimore, plans to enlarge its plant here. Project includes boiler house equipped with cross-drum and marine type boilers, automatic stokers, mechanical blowers, etc., and power house with four 1000 kw. steam engines and generators. Estimated cost, $8,000,000. J. E. Aldred, Chn. Bd. Dirs., Consolidated Gas, Electric Light & Power Co., Baltimore, interested.

Va., Front Royal—The Virginia Orchard Co. plans to build a cold storage room. Estimated cost, $13,000.

Ohio, Akron—The McNeil Boiler Co., Crosier and Sweitzer Sts., is in the market for a 300 to 1000-ton steam hydraulic forging press.

Ohio, Cleveland—The Accurate Machine Co., 1011 Power Bldg., has awarded the contract for the construction of a 2-story, 40 x 160 x 180 ft. factory and office building on East 134th St. and Court Rd., to the Hunkin Conkey Co., 601 Century Bldg. A steam heating plant will be installed in same. Total estimated cost, $250,000.

Ohio, Cleveland—The Board of Education, East 6th St. and Rockwell Ave., will install a steam heating plant in the 1-story school which it plans to build on Miles Ave. Total estimated cost, $100,000. W. R. McCornack, East 6th St. and Rockwell Ave., Arch.

Ohio, Cleveland—The Ohio Forge Co., 2186 East 65th St., is in the market for a 10,000-lb. double frame steam hammer.

Ind., Bloomington—J. Hoadley & Sons Co., Inc., is in the market for a 125 hp. boiler, 100 lb. pressure.

Mich., Flint—The National Bank of Flint and the Genessee Co. Savings Bank will install steam heating equipment in the 10 story, 44 x 120 ft. bank and office building which it plans to build on Kearsley and Saginaw St. Hoggson Bros., 485 5th Ave., New York City, Arch.

Mich., Harbor Beach—The city plans to install pumps, in connection with sewer improvements. B. W. Jenks, Mayor.

Mich., Pontiac—The Board of Education will install a low pressure heating plant in the 1-story, 110 x 200 ft. grade school which it plans to build. Total estimated cost, $100,000. Perkins, Fellows & Hamilton, 814 Tower St., Chicago, Ill., Archs.

Ill., Chicago—The Bormer Drop Forge Co. is in the market for a 2000 lb. steam hammer, a Briggs high duty milling machine and a 3 hp., 230 volt, d.c. motor.

Ill., Chicago—The Independence State Bank, 1215 South Kedzie Ave., will install a vacuum heating plant in the 3-story, 65 x 120 ft. bank and office building which it plans to build on 12th St. and Kedzie Ave. Total estimated cost, $125,000. H. L. Newhouse, 4630 Prairie Ave., Arch.

Ill., Chicago—A. E. Whitbeck, c/o W. W. Ahlschlager, Arch., 111 West Washington St., will install a high pressure steam heating plant in the 3-story, 135 x 150 ft. theater and stores which he plans to build on West 63rd St. and Union Ave. Total estimated cost, $700,000.

Wis., Beaver Dam—The Weyenberg Shoe Co. plans to build a power house and factory. Estimated cost, $150,000. H. J. Esser, 82 Wisconsin St., Milwaukee, Engr.

Wis., Green Bay—C. Hartmann Co. will install 12 direct connected centrifugal pumps, 1200 gal. capacity with alternating current motors, 16 direct connected capstans with a.c. motors, in the 80 x 600 ft. floating dry dock which it plans to build. Total estimated cost, $500,000. Morrison & Beck, 140 South Dearborn St., Chicago, Ill., Engr.

Wis., Sheboygan—The Standard Oil Co., 1209 Pennsylvania Ave., plans to build a filling station and is in the market for 4 best grade gasoline pumps, lighting arrangement and safety apparatus. Total estimated cost, $3000. R. R. John, Engr.

Minn., Bovey—The Board of Education will install steam heating and mechanical ventilating systems in the 3-story, 80 x 140 ft. grade school which it plans to build. Total estimated cost, $150,000. J. V. Coleraine, Secy. Bd. Educ. W. T. Bray, Fidelity Bldg., Duluth, Minn., Arch.

Kan., Kansas City—The city will soon receive bids for furnishing a 5000 kw. generator, turbine driven, 2400 volt, 60 cycle, 3 phase, at 3600 rev., temp. raise 50 degrees C. 170 lb. steam pressure. J. D. Donovan, 1132 Cleveland Ave., Ch. Engr.

Neb., Lincoln—The city will soon award the contract for a 400 hp. Diesel oil engine and generator. A. Dobson, City Engr.

Neb., Omaha—The Skinner Packing Co., 904 1st National Bank Bldg., plans to build an 8-story, 99 x 132 ft. cold storage plant on 12th and Douglas St. Estimated cost, $500,000. H. C. Christianson, 7258 Union Ave., Chicago, Engr.

N. D., Lakota—The city will soon award the contract for constructing 2 concrete wells, 2 motor driven pumps, 2 pump houses, 1 electric transmission line, 1 heating system for elevated tank, two 3 in. motors, etc. E. A. Hughes, City Aud.

N. D., Lisbon—The Lisbon Electric Light Co. plans to improve and equip its plant. Estimated cost, $15,000. H. H. Weeden, Supt.

Mont., Glendive—The State Public Utilities Commission has ordered the Eastern Montana Light & Power Co. to install meters on all services using more than 120 kw.

Mont., Wibaux—The Eastern Montana Light & Power Co. plans to improve and build additions to its plant to supply Wibaux and Glendive, also Beach, N. D. H. Kopf, Mgr.

Ark., Helena—The Helena Gas and Electric Co. plans to build an electric light plant. H. P. Roth, Mgr.

Okla., Perry—The city plans to improve the electric light plant and water-works system. Estimated cost, $100,000.

Utah, Bingham—The city voted $15,000 bond issue for extending and overhauling the electric distribution system, including new street lighting equipment. C. O. Roskelly, Engr.

Ore., Klamath—The California-Oregon Power Co., 131 Leidesdorff St., San Francisco, Cal., plans to build a dam across the Link River in connection with use of the large power plant at Copco, Cal. G. J. Walton, Klamath Falls, Div. Supt.

Cal., Glendale—The city is having plans prepared by H. B. Lynch, Engr., 716 Central Bldg., Los Angeles, for the construction of power and electric generating plants in connection with waterworks improvements. Total estimated cost, $180,000. Bonds must be voted and shares purchased in Verdugo Canyon Water Supply Co. J. C. Sherer, City Clk.

Cal., Independence—The Board of Public Service, Los Angeles, entered into contract with the Big Pine Water Users Assn., Inyo Co., whereby city acquires 2 reservoir sites and sites for 3 power plants (construction will not be undertaken for some time). W. Mulholland, 645 South Olive St., Ch. Engr.

Cal., Inglewood—The city plans election soon to vote on $217,000 bond issue for the construction of a waterworks system. Plans include the installation of wells, pumps, stand pipe, reservoir and distributing system or the purchase of pumping plant and distributing system of the Inglewood Water Co. and extensions and improvements to same. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, Engrs.

Cal., Los Angeles—The Bonnie-Reed Film Manufacturing Co., Niles, plans to build a motion picture plant on Sunset Blvd. and Bronson Ave. Plans include the construction of a power house, laboratories, offices, etc. Total estimated cost, $1,000,000. Train & Williams, 225 Exchange Bldg., Arch.

Que., Quebec—The Harbor Commissioners, Pointe a Carcy, plans to build a cold storage plant. Estimated cost, $1,000,000. St. G. Boswell, c/o Harbor Comrs., Engr.

Ont., London—The Holeproof Hosiery Co., 186 King St., will install a steam heating plant in the 4-story, 150 x 200 ft. hosiery factory which it plans to build on Bathurst St. Total estimated cost, $250,000.

Ont., Parry Sound—The city is having plans prepared by G. Murray, Engr., Parry Sound, for the construction of an electrical plant. Estimated cost, $125,000.

Ont., Port Arthur—The Ontario Hydro-Electric Commission, Toronto, plans to build a 1-story, 100 x 250 ft. power plant with 50,000 hp. capacity on the Nipigon River, Cameron Falls, near here. Work will be done by day labor. Noted Mar. 18.

CONTRACTS AWARDED

R. I., Providence—The U. S. Furnishing Co., Charles St., has awarded the contract for the construction of a 2 story, 40 x 55 ft. addition to its power house, to Day & Zimmerman, 611 Chestnut St., Philadelphia, Penn. Estimated cost, $35,000.

Conn., Plainville—Landers, Frary & Clark, Commercial St., New Britain, has awarded the contract for the construction of a 40 x 40 ft. boiler house on Woodford Ave., to the Torrington Building Co., 197 Water St., Torrington. Estimated cost, $20,000.

Fla., Jacksonville—The Ward Engineering & Battery Co., 239 13th St., Miami, has awarded the contract for the construction of a 1 story, 50 x 105 ft. battery station on Forsythe St., to O. P. Woodcock, 403 Main St. Estimated cost, $10,000.

N. Y., New York—The National Ice & Coal Co., 103 Park Ave., has awarded the contract for the construction of a 2-story, 120 x 120 ft. refrigerating plant at 8-10 Tompkins St., to J. Brody, 8-10 Tompkins St. Estimated cost, $75,000.

Neb., Sterling—The city has awarded the contract for the construction of a transmission line from Sterling to Tecumseh, to the Martz Construction Co., Seward. Estimated cost, $4681. E. H. Johnson, City Clk.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.55

Bituminous

	Clearfields	Cambria and Somerset
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.50
Philadelphia, gross tons	4.20@4.90	5.00@5.55
New York, gross tons	4.50@5.25	5.35@5.95
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.80

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90@$3.50	$2.95@$3.50
Cambria County (good grades)	2.80@3.10	2.95@3.10
Clearfield County	2.65@2.95	
Reynoldsville	2.65@2.95	2.85@3.00
Quemahoning	2.85@3.10	2.95@3.10
Somerset County (best grades)	2.80@2.95	2.95@3.10
Somerset County (poorer grades)	2.50@2.75	2.75@2.95
Western Maryland	2.50@2.75	2.65@2.85
Fairmont	2.10@2.35	2.35@2.50
Latrobe	2.25@2.40	
Greensburg	2.35@2.40	2.35@2.60
Westmoreland	2.60@2.75	2.65@2.75
Westmoreland run-of-mine	2.40@2.65	2.40@2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.90	3.80
Stove	6.10	7.95	Boiler	2.70	3.70
Nut	6.20	8.05	Barley	2.40	3.30
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.75	$3.25
Mine-run	2.35@$2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.65
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.20	2.20	1.60@1.70
Screenings	2.05	2.05	.95@1.10
3-in. lump	....	2.30	.....
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St. Louis is $1.10 other rates 92½c.

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		75c. per ft.
Common, 2½-in.		30%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.55	$0.40	$0.30

Steam—Discounts from List

First grade..... 25% Second grade.....35% Third grade.....40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 30%
Standard..... 40%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	30%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ¼- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List

For low-pressure heating and return lines { 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	7.2	8½	14½
Fiber or sponge	8	10	6	13	9	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4.75	3½ to 4½	5½
Gear	4½	9	4½	7.5	7½	8
Car journal	22(gal.)	21 (gal.)	3½	4.9	9¼	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1.55	$1.55	$1.68	$1.65	$1.66	$1.65
5-gal. cans	1.70	1.65	1.85	1.80	1.86	1.75

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	13.00	14.50	11.25	11.50	13.00	10.50
25- and 50-lb. kegs	13.25	14.75	11.50	11.75	13.25	10.75
12½-lb. keg	13.50	15.00	11.75	11.00	13.50	11.00
1-lb. cans	15.00	16.50	13.25	13.00	15.00	13.00
5-lb. cans	16.00	17.50	13.25	13.50	16.00	13.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. car boys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅝ and smaller	45%	55%	50%
Tinned	35%	55%	45%

Button heads, ½, ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6.37 Cleveland...$5.00 Chicago...$5.47 Pittsburgh... 4.65

Coneheads, same sizes:

New York....$6.25 Cleveland...$5.10 Chicago...$5.57 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50–35.50 at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL—Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	77.00	93.00	75.00	90.00
Commercial	42.00	50.00	18.50	30.00	15.00	30.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.00
Chicago	16.50	15.00

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.

For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Inches	Steel Black	Steel Galvanized	Inches	Iron Black	Iron Galvanized
⅛, ¼, and ⅜	50½%	24%	⅛ to 1¼	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	25%	⅛ to 1¼	39½%	24½%
½	51½%	39%			
¾ to 1¼	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39½%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
⅛ to 3 in. steel butt welded	47%	31%	46½%	31 %	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	42½%	27½%	51½%	41%

Malleable fittings, Class B and C, from New York stock sell at list + 12½%. Cast iron, standard sizes, 10% off.

Note—Recent pig-iron reduction will lower price of steel pipe. New discounts will be given next month.

BOILER TUBES — The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3¼ in.	30½	3 to 3¼ in.	1
2¼ in.	24	2½ to 2¾ in.	+ 1
1¼ to 2 in.	19½	2 to 2¼ in.	+16
		1¾ to 1⅞ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

Per Net Ton		Per Net Ton	
1 in.	$327	1¾ in.	$207
1¼ in.	267	2 to 2½ in.	177
1½ in.	257	2½ to 3¼ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$222.00
No. 12 solid	135.00	170.00	211.00	290.00
No. 10 solid	185.00	235.00	255.00	325.00
No. 8 stranded	235.00	325.00	345.00	450.00
No. 6 stranded	370.00	472.00	625.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
¾	.....	.....	$18.24	$19.38	$5.76	$6.12
1	$76.50	$81.60	18.24	19.38	6.72	7.14
1¼	101.20	108.10	24.00	25.50	9.60	10.20
1½	149.60	159.80	35.52	37.74	12.48	13.26
1¾	202.40	216.20	45.45	48.15	17.17	18.19
2	242.00	258.50	60.60	64.20	21.21	22.47
2½	325.60	347.80	111.11	117.70	28.28	29.96
3	514.80	549.90	181.80	192.60	40.40	42.80
3½	673.20	719.10	484.80	513.60	60.60	64.20
4	837.20	892.40	1,070.60	1,134.20	80.80	85.60
	1,013.70	1,079.10	1,237.25	1,310.75	101.00	107.00

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ⅜ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	Coils....55% Off... Less coils, 40% off
½	250	.06	
¾	250	.09	
1	200	.12	
1¼	200	.15	
1½	150	.18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	.....
T. P. S. B.	.81	1.80	.....
D. P. D. B.	.78	2.10	.....
T. P. D. B.	1.35	3.60	.....
T. P. to D. P. D. B.	.90	2.52	.....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	28.40
No. 18 cotton parallel	25.00
No. 16 cotton parallel	32.00
No. 18 cotton reinforced heavy	35.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.00
No. 18 cotton Canvasite cord	29.00
No. 16 cotton Canvasite cord	35.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
2-map. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00
Discount: Less 1-5th standard package	30%	
1-5th to standard package	40%	
Standard package	52%	

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package	$5.25 C
0–30 ampere, less than standard package	7.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B— Watts	Plain	Frosted	No. in Package	Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$14.00	$13.90	$25.00
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$11.00	$14.50	$30.40	$21.00	$16.00	$33.00	$10.95	$15.25	$27.75
10	19.20	25.70	49.00	27.20	31.00	69.00	20.25	24.25	46.90
8	26.95	34.25	67.00	38.00	42.00	78.00	27.60	32.60	.....
6	43.90	46.20	.....	.....	65.00	130.00	48.25	54.75	.....
4	62.35	65.15	.....	.....	93.00	.....	66.90	73.75	.....
2	92.60	96.25	.....	.....	140.00	.....	96.00	104.50	.....
1	120.95	125.20	.....	.....	182.00	.....	121.00	136.40	.....
0	164.80	164.80	.....	.....	242.00	.....	169.00	174.60	.....
00	.....	203.35	.....	.....	290.00	.....	203.50	214.00	.....
000	.....	248.40	.....	.....	360.00	.....	246.00	257.50	.....
0000	.....	302.55	.....	.....	435.00	.....	295.50	358.50	.....

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

⅛ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	45c. lb.
No. 18 B.&S. regular 1-lb. coils	47c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%